ADKINSON and ASSOCIATES

PV HYBRID RESIDENTIAL POWER
GENERATING SYSTEM

FINAL REPORT

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FINAL REPORT

PREPARED FOR:

Renewable Energy Division
Coal and Alternative Energy Branch
Energy, Mines and Resources Canada
Ottawa Canada
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PREFACE

This Report is a Final Report on the work performed under the subject contract installing and monitoring a PV Hybrid Residential Power Generating System.

It is intended to describe the work done during the course of the installation and provide information on performance of the PV Hybrid Power Generating System.

ABSTRACT

This Report summarizes the design,installation and monitoring of a photovoltaic power generating system on a staff residence in the remote community of Trout Lake, Northwest Territories. The system design and hardware is described along with the operational results.

A monitoring system has been in place recording the performance of the PVPGS however due to construction delays in completing the residence, it has not been occupied and operational load data is not yet available.

ACKNOWLEDGEMENTS:

The author wishes to acknowledge the contributions to this project by a number of participants including Negentropy Inc. for the performance simulations,Sun Direct Energy Inc. (now Photron Canada) for the design and installation work, and the personnel of both the Northwest Territories Housing Corporation and Canada Mortgage and Housing Corporation.

Special thanks are due to Mr. Karl Jorgenson, a local resident and neighbour who has faithfully changed the data tapes and forwarded them to us for processing.

Acknowledgement is also given to the University of Alberta, Electrical Engineering Dept. for the loan of the two pyranometers used in the solar monitoring.

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EXECUTIVE SUMMARY

A PV Hybrid Power Generating System has been designed, installed, and monitored on a staff residence in a remote community, Trout Lake, in the Northwest Territories. The system comprises not only the solar array as power input but also an auxilary gasoline driven generator which is activated automatically to re-charge the batteries during the winter and periods of bad weather.

The project was initiated in conjunction with the Canada Mortgage and Housing Corporation (C.M.H.C.) and the Northwest Territories Housing Corporation (N.T.H.C.) to demonstrate the feasibility of a PV Hybrid Power System in a remote residence.

As a result of previous work looking at low voltage limit power systems in northern areas, it had been concluded that a backup generator would be required to provide reasonable amounts of power in areas north of 55 degrees for continuous operation throughout the Canadian winter. In order to deliver electrical power of a quality similar to southern residences, an inverter was included in the system to deliver 60 Hz 110 volt AC power to the residence.

A power budget was established in the initial phase of 7.4 kilowatt average daily consumption and it was to satisfy this load that the systems design was tailored.

Computer simulations were made utilizing hourly solar data as input to the Negentrory Inc. model in order to define the opitimum parameters of array, battery, generator sizes, operational algorithms of the generator, and starting and stopping set points for the generator's operations.

The functioning of the system is completely automatic and transparent to the user as the solar array generated power is stored in the 24 volt battery storage component from which the power is fed to the residential loads via a DC/AC inverter which has an extremely low current drain when not in use. When the batteries' state of charge

falls to approximately 30%, the generator is automatically started and power is delivered to the residential circuits as required, with the surplus being stored in the battery sub-system via a 200 amp heavy duty battery charger. This concept enables the generator to run at relatively high efficiency at the times when it is running.

The final design comprises an adjustable tilt solar array of 672 watts peak, a 24 volt lead antimony deep cycle battery of 1325 amp hours, a 3000 watt inverter, and 6500 watt gasoline driven generator. The hardware cost for the system was $23,928.30 plus freight costs of $3,534.00 for a total delivered hardware cost of $27,462.00.

The system was installed at the end of September 1986 in accordance with the original schedule, however the residence was not completely finished until late spring 1987 and no occupant has yet (October 1987) been living in the house.

A monitoring system was installed along with the PV PGS to record environmental and electrical performance data. Without a tenant little of the operational data is useful, however, good environmental data has been recorded.

The PV PGS was left in a standby mode after the initial installation and was subsequently re-activated in March of 1987 to full operational condition. It was expected that the unit would soon be occupied.

As a lack of occupant of the dwelling prevented any meaningful load data being obtained during the scheduled period of the contract, it has been recommended that the monitoring period be extended for an additional twelve months or at least until the summer of 1988 in order to obtain complete operational data for the system.

While the unexpected installation of a community diesel electric supply grid might suggest the PV system is superfluous, it actually provides an excellent opportunity for cost comparisions, provided a tennant is in occupation of the residence.

PV HYBRID RESIDENTIAL POWER GENERATING SYSTEM

SECTION 1.0 INTRODUCTION

One of the tantalizing promises of PV technology has been the eventual capability to provide improved living standards for the world's rural and native populations. The concept of a minimal electrical power package to provide the basic amenities of lighting, water pumping, TV, communications and refrigeration to even the most isolated residence is essentially now feasible with photovoltaics.

Although considerable numbers of remote residences are now powered with PV systems in certain areas of the U.S., notably northern California (1), few Canadian citizens have enjoyed such benefits. Wide spread use has not yet occurred in Canada for several valid reasons. One is lack of design information, along with lack of hardware availability; another is the apparent drawback of extreme daily variation of solar radiation throughout the year in many of Canada's remote areas, along with the additional cost of compensation for this variation. Whereas the large percentage of government controlled housing in the North might be expected to be a focus for activity, this has not occurred because of the complexities derived from multiple jurisdictions.

The commitments of the government of Canada to provide housing for native Canadians through the Department of Indian & Northern Affairs, provincial and territorial programs, provide a basic future market for remote residential PV systems and, with the prospect of numerous land claim settlements being finalized in the near future, a brisk independent commercial market is likely to develop. Vacation cottages are also seen as a developing market.

The increase in demand for improvements in the rural and native housing in Canada, in conjunction with the increasing availability of appropriate hardware as well

as satellite television programs, indicate that a reliable, low cost PV electrical power generating system package will now be able to make a significant contribution to the quality of life and education in remote areas.

In addition, the projections for this rapidly developing technology indicate that PV power generating systems will become economic and will become a major component of residences in commercial operations in the near future. For this reason, current development work will provide a sound base for the understanding and the optimum utilization of this new and useful technology in the programs of tomorrow, as well as the practical benefits of today.

Commercial opportunities for exporting well designed PV minimum power packages are enormous, yet a prime requirement suggested by the marketer (reference 2) is the need for proven system performance with reliability in the home country. Thus there was the need to initiate performance monitoring as soon as possible and the work performed in this contract included this activity.

A previous investigation into the use of low voltage photovoltaic systems for remote residences (reference 3) highlighted the difficulty of an economical design for a pure PV power source for remote residences in areas north of 60 degrees north latitude.

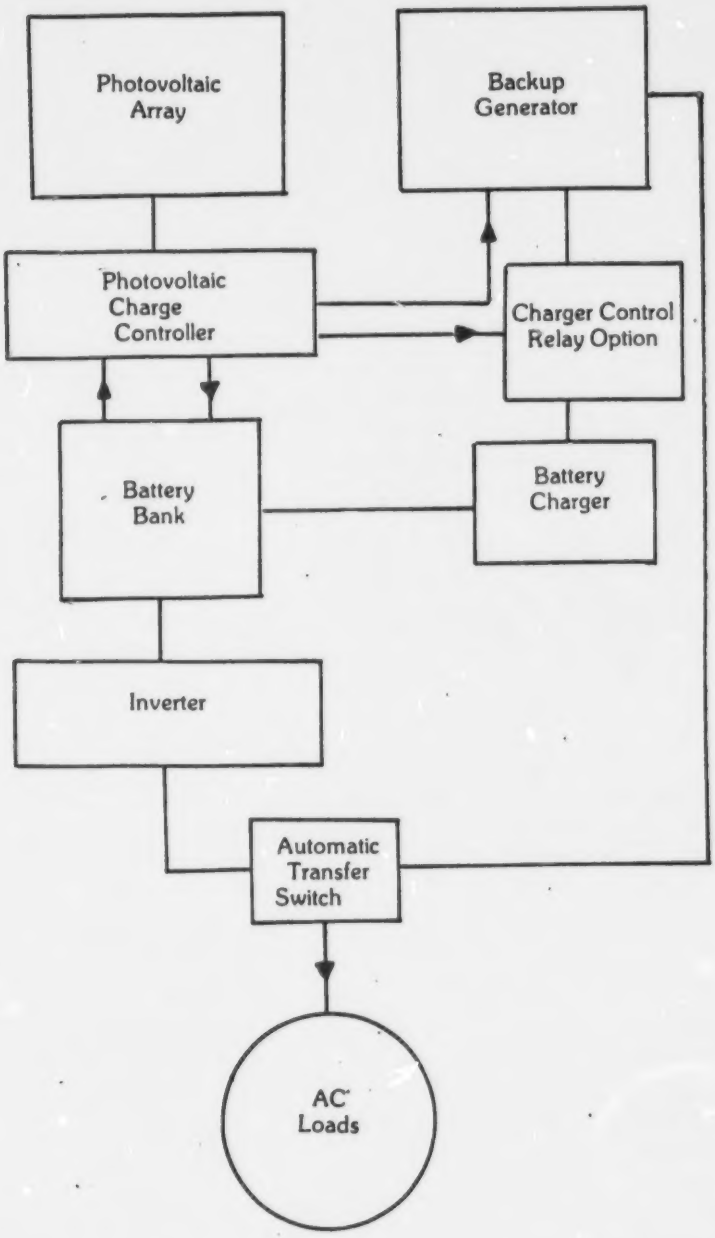
To supply the annual requirements of a load of approximately only one kilowatt hour per day, a PV system at Fort Smith requires an array of 680 watts peak and a storage capacity of 3800 amp hours, as reported in reference 2. Paradoxically, while only this minimal amount of one kWhr/day is available during the winter period, during the summer operation, because of the inbalance of the array and battery components, approximately 20,000 amp hours of energy would be lost due to the inability of the system to store it. The use of the PV/Genset approach provides for a much better balanced and economical PV component. One of the recommendations of this previous report (reference 2) was to develop an optimized design for PV/Genset system for a remote residence; this contract work was an outgrowth of that recommendation.

The concept of a hybrid PV/Genset combination is perceived to be the most practical answer for remote residences in these northern areas. With this technology the PV system powers the residence for the majority of the year, however, when winter periods of reduced sunlight occur, a standby conventional fossil fueled genset supplements the PV and maintains sufficient energy in the storage batteries for continued system operation. A schematic illustration of the components and their relationship is shown in Figure 1.

Another feature of the hybrid technology is the ability to go beyond the low voltage concept and to provide 110 volt ac household power to the residence continously through the use of an inverter. While a pure PV system can also employ an inverter, the hybrid system with a transfer switch and larger capacity generator can provide intermittently (when the generator operates) a larger amount of power and a higher voltage output of 220 volts if required for tools etc. Thus a flexible power source becomes available for the remote residence and it operates primarily from the solar input for the majority of the year and is able to function throughout the winter with a minimum of conventional fuel.

The reduced number of operating hours of the generator set when it is used in this hybrid mode results not only in the extensive fuel savings but reduced maintenance costs and consequent extended life of the genset itself.

Canada Mortgage and Housing Corporation (CMHC), has a particular interest in residential applications of the photovoltaic technology. As Canada's national agency responsible for not only financing but also supplying housing units across Canada through its local regional offices and affiliated agencies, CMHC becomes involved in both native and rural housing, much of which is located in remote areas. Through their Project Implementation Division, a small, low voltage PV system was installed in 1984 in Rock Creek, British Columbia for a remote residence. While operating successfully, this installation has not had detailed performance monitoring data available which would be of use in future planning for CMHC.

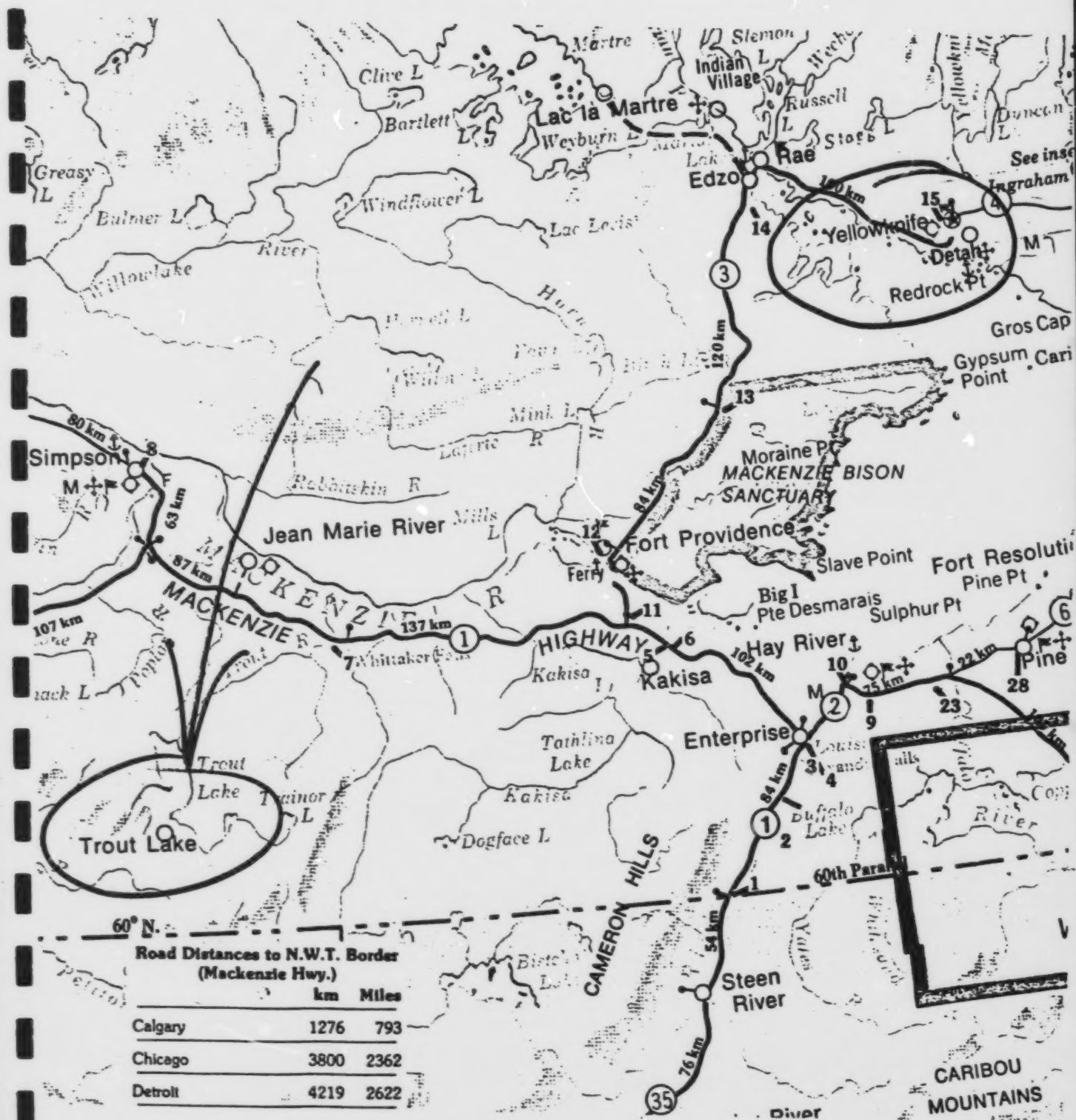


"Figure 1"

BLOCK SCHEMATIC OF HYBRID PVPGS COMPONENTS

New work was required to investigate the potential of larger PV systems that could supply residences with a quality of power more similar to that of the conventional grid connected residence. This issue is addressed in this contract, which provided for the design, installation and monitoring of a hybrid PV/Genset power generating system for a remote residence at Trout Lake in the Yellowknife area of the Northwest Territories. This is in association with the Northwest Territories Housing Corporation. Trout Lake is located at 60.4 degrees north latitude and 121.3 degrees west longitude.

The Northwest Territories Housing Corporation (NTHC) initiated a program in 1986 to erect 4 staff dwellings in various locations, one of which was at Trout Lake. This is a small native community listed as having 61 residents (20-22 residences) in the summer of 1986 and was without any grid power. This staff house is a two storey,three bedroom energy efficient dwelling utilizing log construction. Original plans were to utilize bottled gas for lights and refrigeration however, plans were modified to accommodate a hybrid PV/Genset power generating system. Construction of the unit was scheduled for the summer of '86 with occupancy expected in September or October 1986. The power generating system, along with the monitoring equipment, was scheduled for installation in late summer 1986, with the monitoring of the system performance, along with the equipment loads, scheduled until June of 1987.



"Figure 2 - Location Map"

SECTION 2.0 OBJECTIVES

This contract work addressed the application of Hybrid PV/Genset power generating systems to remote residences in general, and in Canada's north in particular.

The objectives of the contract were to confirm this viability of the technology for providing power systems to remote residences and to provide information from the monitoring data to improve the design, control, and hardware aspects in future installations. The monitoring data was intended to provide information not only on the supply side of the system ie. solar input and output but also to provide information on the demand side in the form of the load requirements of the residence.

The major work of the contract provided for the detailed design and installation of a Hybrid PV/Genset power generating system for a new staff residence constructed by the Northwest Territories Housing Corporation at Trout Lake a northern location in the Yellowknife area. The residence was scheduled for construction in 1986 and was made available in conjunction with CMHC for research purposes in co-operation with the Northwest Territories Housing Corporation. (See Figure 2).

SECTION 3.0 METHODOLOGY

The work on the contract can best be broken down into three major phases. The first is the design phase, the second being the installation, and the third being the monitoring phase of the system in operation.

The design phase details are described in full in the Interim Report (4). In summary it involved the development of an anticipated power consumption budget for the proposed residence and then performing a number of simulation runs on a computer with various design parameters of the solar array, the battery capacity, and the generator set capacity. In addition to these, general operating philosophies were investigated whereby the generator set ran completely on automatic start up when the battery system was low or, alternatively, a routine two or three hour run on Saturday morning, along with automatic operation during the balance of the period. The solar input was assumed to be similar to that of the Fort Smith location which is approximately the same latitude as Trout Lake but some 520 km to the east.

After the initial design parameters were decided, variations on these were defined and simulation runs made on the computer to assess the results of the various design options.

The final design was then priced and the work done to date described in an Interim Report which was subject to approval before the installation phase could be commenced. As time was of the essence to meet the installation deadline of September, permission was received in the original stages to place tentative orders for the long lead items such as batteries and control equipment with fixed cancellation charges so that the installation could proceed in time, if and when the approval was received.

The installation sub-contractor Sun Direct Energy Inc., of Colinton Alberta was also involved in the design process and the definition of the control equipment.

Equipment was ordered and assembled in Fort Simpson, at the warehouse of the charter aircraft operator Simpson Air, with whom arrangements had been made to fly the equipment and personnel into the site, as the community has no continuous water access nor land access except during the winter over a winter ice road. The hardware and personnel were flown into the site in a twin otter aircraft in two trips and the 2 man installation crew lived on site for a week. As there was no commercial accommodation available in the community, a construction trailer that had been left in the community from a previous contract was utilized for living quarters during the installation time.

The installation was completed at the end of September 1986 and was inspected and accepted by the Northwest Territories Housing Corporation. The residence itself however was not completed as anticipated, as all the interior finishing and windows had yet to be completed. To prevent potential abuse by the various sub-contractors involved in the finishing process of the residence, the PVPGS was left in a semi operational state such that the generator would not be operated automatically nor would the inverter be used to supply power to the construction tools.

A manual of operations was developed to describe the hardware system to the occupant and maintenance personnel and excerpts from this manual are enclosed in Appendix C.

A performance monitoring system was included in the final design and was installed along with the operational hardware. The monitoring device was a Campbell Scientific 21X Micrologger which was programmed to read and record the following items:

- Global Solar Radiation (on the horizontal)
- Total Solar Radiation (on the plane of the array)
- Ambient Temperature
- Battery Temperature
- Array Output Current
- Battery Load Current
- Battery Terminal Voltage
- 110 Volt AC Load Power
- 220 Volt AC Generator Output

The data was recorded internally in the datalogger memory and then dumped routinely onto a standard tape cassette

connected to the datalogger. The cassette tapes were changed once per month and forwarded to Adkinson & Associates for formatting and analysis.

Initially the tapes as received were sent to a service house to re-configure the data on an IBM PC disk which was then formatted and analyzed at Adkinson and Associates facilities. Due to the cost and inconvenience of this conversion process equipment, hardware and software were obtained in order to do the data translation and conversion directly at Adkinson & Associates Ltd. facility thus speeding up the conversion of the data and providing a more flexible means of conversion.

A second trip into the site by Mr. Ron LaPlace of Sun Direct was made at the end of March in order to re-commission the system, as it was anticipated that the residence would soon be occupied. At this time the system was re-configured for completely automatic operation and some changes were made to the datalogging program in order to eliminate some minor bugs in the original process.

An unexpected event occurred during the winter that created some uncertainty as to the continuation of the program, when a diesel generating system for the community was installed and power became available to the residence. As this uncertainty was unresolved at the original end of contract date, the contract was extended until the end of September, with the expectation that a resolution would be made by that time of the future of the project.

SECTION 4.0 RESULTS

The load budget was developed early in the design process in conjunction with CMHC and NWTHC personnel and was a result of an assessment of the anticipated requirements and appliances of the residence. The final design load was approximately 7.4 kilowatt hours of electrical power per day; and the details of this budget are given in Figure 3 and the derivation of the figures is discussed in detail in Section 2.2 of the Interim Report.

The intent of the system design was to make the operation of the PVPGS as automatic as possible, without attention by the house occupant. The system operates from electrical storage batteries which are charged from the sun via the photovoltaic array and from the auxilliary generator set which activates automatically when the battery state-of-charge decreases to a level of 30% as determined by the battery terminal voltage. The genset charging operation is terminated when the battery is filled to 70% of its capacity so that there will still be storage room for the output of the photovoltaic array.

The power is delivered to the household circuits via an inverter that changes the direct current output of the batteries to the standard 110 volt ac 60 Hz power which is commonly used in a power grid. This allows for standard appliances, lights and equipment to be used in the residence. The automatic operation of the genset can be overridden manually so that when heavy use is anticipated for electrical power in the residence, such as vacuuming plus clothes washing, the ac power produced by the genset is fed directly to the appliances without going through the storage batteries and inverter components of the system. When in this mode of operation, the surplus power not required for the operation of the residence loads is fed to the battery charger and stored in the battery component, ensuring that the genset will run essentially at full power, where it is most efficient.

ADKINSON AND ASSOCIATES

PROJECT DATE: June 24/86
Staff Res. Trout Lake
NWT LOAD ESTIMATE WORKSHEET FOR SOLAR POWER REQUIREMENTS

	APPLIANCE	NUMBER	WATTS	AV.HRS /day	kWhrs /day	days /wk	kWhrs /wk	Monthly kWhrs	Annual kWhrs
1	Lights ,fluorescent	2	20	4	0.16	7	1.12	4.85	58.2
2	Lights, fluorescent	4	40	1	0.16	7	1.12	4.85	58.2
3	Lights, misc.	2	100	2	0.4	7	2.80	12.13	145.6
4	Radio	2	10	6	0.12	7	0.84	3.64	43.7
5	TV 25 in colour	1	130	3	0.39	5	1.95	8.45	101.4
6	VCR	1	30	3	0.09	5	0.45	1.95	23.4
7	Stereo	1	15	5	0.075	6	0.45	1.95	23.4
8	Refrigerator	1	250	10	2.5	7	17.50	75.83	910.0
9	Radio Telephone	1	10	24	0.24	7	1.68	7.28	87.4
10	Electric clocks	2	4	24	0.192	7	1.34	5.82	69.9
11	Pump, pressure 1/8 hp	0	240	1	0	7	0.00	0.00	0.0
12	Pump, DHW 1/30 hp	0	30	2.5	0	7	0.00	0.00	0.0
13	Sewage heat trace	0	200	1	0	7	0.00	0.00	0.0
14	Can Opener	1	100	0.01	0.001	5	0.01	0.02	0.3
15	Microwave	1	1200	1	1.2	5	6.00	26.00	312.0
16	Food Processor	1	1200	0.1	0.12	5	0.60	2.60	31.2
17	Exhaust fans	0	44	0.25	0	7	0.00	0.00	0.0
18	Iron	1	1500	0.05	0.075	7	0.53	2.28	27.3
19	Dryer(hair)	1	1500	0.5	0.75	3	2.25	9.75	117.0
20	Vacuum	1	750	0.5	0.375	5	1.88	8.13	97.5
21	Stove fan	1	44	24	1.056	7	7.39	32.03	384.4
22	Fire alarm	0	1	24	0	7	0.00	0.00	0.0
23	Shaver	1	15	0.25	0.004	7	0.03	0.11	1.4
24	Washer Clothes	1	900	0.5	0.45	7	3.15	13.65	163.8
25	Misc. Tools	1	200	0.5	0.1	7	0.70	3.03	36.4
26					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
	MAXIMUM DAILY LOAD				8.458				
	Total kWhrs per week						51.78		
	Total kWhrs per month							224.37	
	Total kWhrs per year								2692.4
	Average daily load				7.40				

DESIGN LOAD FOR PVPGS AT TROUT LAKE PROJECT
FIGURE 2

The occupant of the remote residence will then use its appliances, lights, etc. in the same fashion as an urban one who is hooked up to the grid, with the exception of manually activating the genset when a heavy use of power is planned. With the exception of this, the operation is completely automatic and, unless a failure occurs in the controls, only routine fuelling of the genset and normal maintenance operations on the genset and batteries is required.

The final design of the system included an adjustable tilt solar array of 672 watt peak Solarex modules, a 24 volt lead antimony, deep cycle battery system manufactured by GNB with a capacity of 1325 amp hours and a 3000 watt inverter manufactured by Vanner. The design details are shown in Figure 4 "Specification Sheet for PV System". The auxiliary generator set selected was a Honda ES 6500 unit with a maximum output rating of 6500 watts powered by regular automotive engine gasoline.

The hardware cost for the system was $23,928.30 plus freight costs of $3534 for a total delivered hardware cost of $27,462.00. The breakdown of these costs are given in Figure 5.

The 2 position adjustable array provides for a 75 degree angle of inclination to the horizontal for a winter setting, and a 34 degree angle for the summer.

The design and ordering of the components proceeded without any real difficulty. However, as the installation time drew near and the electrical sub-contract work on the residence itself had not yet been started it was felt prudent to meet with the sub-contractor at a pre-installation meeting at Fort Simpson, in order to co-ordinate the two components of the total electrical system for the residence.

Bad flying weather forced the delay of the delivery of the hardware into Trout Lake as well as the arrival of the installation crew who were forced to lay over for 3 days awaiting the appropriate flying weather at Fort Simpson.

The most disappointing aspect of the project has been the lack of an occupant for the house to develop operational loads to fully exercise and prove the PVPGS. The residence was not completed as originally scheduled in

sysspec1

SPECIFICATION SHEET FOR PV SYSTEM

Ident.No.: 123 PV Hybrid Residential

Date
Oct. 31/8

GENERAL:

Location:	Trout Lake NWT	Latitude & Longitude	60'N 118' W appr
Owner:	NWTHC	Elevation:	
Identification:	Trout Lake Staff Residence	Solar Data Source:	Fort Smith
Type of Load:	Residential	Solar Data Site:	AES
Avge Daily Load AH:		Operating Months:	12
Avge Daily Load Whr	7.4 kWh	Min. Solar Month:	Dec
System Voltage:	24/110	Avge Daily Rad.MJ/m2:	.0033
		Equivalent Sun Hrs:	.915

PV ARRAY:

Array Rating Wp:	672	Quantity of Modules:	16
Module Model:	SX 42	Array O/put Voltage:	24
Module W x L xD :	445 x 965 x 54 mm	Module Rating Wp:	42
Array Area m2 :	6.87	Module Output Amps:	2.6
Array Incl. Deg.:	60	Series/Parallel:	2 X 8
Array Orient.Deg.:	180	Manufacturer:	Lenbrook/Solarex

REGULATOR/CONTROLLER

Regulator Type:	Series	Manufacturer:	Photron
Model No.:	BVR-30TC	Capacity Amps:	30
Blocking Diode Inc.?	no	No. Required:	1
Location:	Control Panel	Comments:	see Sec.3.6

BATTERIES:

General Description:	PbA deep cycle			Days No Sun Storage:	3 -4
Manufacturer:	GNB			Min. Cell Temp.C:	10
Electrical:					
Capacity @25'C:	1325	Amp.Hrs.		Cell Model No.:	NAL860
Discharge Rate:	100	Hours		No. Cells Req'd.:	12
In/out Efficiency:	80	%			
Physical:					
Cell width mm.:	369	Length:	187	Height: 562	Weight Kg: 80
Battery Width mm.:	738	Length:	1122	Height: 562	Weight Kg: 960

Rack Location: Matting Model No.: S04-167-585

POWER CONDITIONER

General Description:	24V DC/110V AC Inverter -Series 20				
Model No.:	PF 24/3000	Eff.@ 95%:	90	Manufacturer:	Vanner
Output Volts:	110VDC	@ 50%:	93	Location:	Control panel
Rated Capacity:	3000 W	@ 10%:	75		
Surge Capacity:	4800W	Time min.:	10		see Sec. 3.5
Physical:					
Width cm.:	39.37	Height:	15.875		
Length cm.:	31.75	Wt. Kg.:	23.18		

FIGURE 4

syscosi

Date:June 26/86

COST ESTIMATE FOR PV SYSTEM HARDWARE

Owner: NWTHC
Project: Rem. Res. Hybrid PV/GensetLocation: Trout Lake NWT
Description: 672 Wp 1325 AH 6.5Kw generator backup

	Item Description	Quantity	Unit Cost	Lot Cost	Weight	Comments
1.	Modules	16	500	8000	288	inc. cables
2.	Cabling	1	240	240	80	
3.	Support Rack	4	250	1000	150	
4.	Tranzac Control	1	995	995	15	
5.	Batteries	12	320	3840	2256	
6.	Batt.Matting	1	20	20	10	inc.cables
7.	Panel Hardware	1	663.3	663.3		
8.	Control Panel	1	1325	1325	200	
9.	DC Charger	1	1900	1900	175	
10.	Inverter	1	2250	2250	65	
11.	Gen-set	1	2950	2950	295	
12.	Misc.	1	350	350		
13	Gen. Start Adap	1	395	395		
	PV TOTAL			$23928.30		

Total Weight: 3534 pounds
Freight Rate: $1.00

Total Freight: $3534.00

TOTAL PV HARDWARE DELIVERED COST : $27462.30

FIGURE 5

the fall of 1986 due to a number of unfortunate circumstances including a malfunctioning heater which caused extensive smoke damage and created the need for complete refinishing of the house interior.

The monitoring system was installed at the time the system hardware was installed at the end of September 1986 and data tapes were received monthly with only two exceptions throughout the contract period. These months were February when the tape was blank as received, and March when the data was lost during the site visit due to an inadvertent momentary disconnect of the battery unit. The original datalogging software required some minor corrections on the recording side of the load and changes were made to this when the re-commissioning was done on the PV system at the end of March.

Although the generator set was left in a standby mode and was not intended to be used during the construction period, personnel onsite did start the equipment and the generator set was used throughout the winter. Additionally from the monitoring data it was evident that use was made of the inverter system, which ran the batteries down to an extremely low state in the month of January with the resultant malfunction of the monitoring system for February and March.

When the installation contractor was in at the site at the end of March a new program was entered into the datalogger and some minor changes made to the wiring during the recommissioning of the automatic controls of the system. Unfortunately it would appear from the data since received, to have ended up with some incorrect wiring on the monitoring equipment with spurious readings being received due to the erroneous connections. Inconsistant data was received on the generator start and run times prior to April.

Consistent data has been received on the solar input to the system and monthly reports have been developed indicating an array efficiency in the neighbourhood of seven to eight per cent relative to the solar energy received on the plane of the array. Copies of the monitoring reports and monitored data are included in Appendix D of this report.

A minor interface wiring change is required on the next site visit by Mr. R. LaPlace to activate the remote "manual generator start" function of Gen-Wizard control unit. This function is temporarily not working and to start the genset manually at this time, it must be done at the generator, not from the control panel in the residence.

SECTION 5.0 DISCUSSION

One of the most disappointing features in this operation of this contract was the delay in the completion of the residence and the subsequent lack of occupation by a tenant. The delay in the completion was a result of a number of factors, but further complicating the matter from the aspect of the contract was the change in the site superintendents that also occurred with the extended completion time. There were at least 3 superintendents on site from the time that the power generating system was installed. This meant less co-ordination with the site superintendent as the successor superintendents were not fully acquainted with the details of the system other than through the Operation's Manual and some verbal communication from the NWTHC Construction Branch Office.

Changes also occurred in the construction branch personnel responsibilities, and again new personnel were introduced into the operation which had not been involved with the project from the start. All the parties involved were most co-operative at all times and the above comment was not meant to detract from their efforts, but only to indicate that without the personal background of the beginnings of the project, the co-ordination sometimes is less than ideal.

Partly because of these changes and partly because there has been no occupant, little or no maintenance has been performed or site records kept of fuel etc. The array angle of inclination was not changed during the summer nor is there any record of oil changes in the Honda generator. As the system has not been used to any extent however, this has been of little consequence on the performance of the PVPGS.

A further complication developed with an unexpected introduction to the community of a diesel generation system that was set up during the winter of 1987, when it was not originally scheduled until at least 3 years downstream. The availability of this grid connection provided a more attractive option to the territorial department of public works for maintenance reasons, rather than accepting the responsibility of a PV/Hybrid PGS.

It is to be noted that the system design for this project provides for a completely automatic operation of the generator and transfer switch as well as the charging regime for the batteries. This automation adds to the complexity and cost to the system, thus a more basic design whereby, the generator start, the battery charger connection, and the inverter disconnect would all be performed manually, would eliminate the transfer switch, and allow a more basic generator and a more economical charger unit. Without these features being automated, a cost saving in hardware would be expected of approximately $2500. The design decision in this case of a remote location and lack of technical personnel nearby, was that the additional automation would be warranted to make the PVPGS as transparent as possible to the user.

5.1 DESIGN

In performing the simulation runs of the original design there were a number of parameter options that had to be established for each run. These included the size of the array, the size of the battery, the size of the generator, the size of the charger, the size of the inverter, the run profile ie. running on Saturday routinely or only on demand, and also the battery state-of-charge percentages for initiating the starting of the generator and its shut-down. Obviously, many combinations of the parameters are available and it was necessary to run approximately 50 simulations before the initial design was established. The parameters were set on the basis of certain assumptions, and do not necessarily reflect the actual real life operating conditions. It would be of interest to utilize the actual system parameters as finally defined when the load is established to rerun the simulation program and determine its correlation with the monitored results.

The hardware selection has also been influenced by considerations other than the theoretical ideal due to practical and political considerations. For instance the choice of the generator set was limited to two makes whose dealers were established in the area and who could service the equipment and so a complete choice of generator options was not available. Additionally, when the requirement of an automatic start capability for the

generator was considered the options of the available models again were restricted.

In reviewing the costs of the design as established, the actual hardware costs in place were relatively close to the original estimates. As mentioned previously the incorporation of the automatic features for the system did add to the cost and could be eliminated if capable operators were to be involved.

5.2 INSTALLATION

The hardware item with the longest lead time for delivery was the battery storage component which ran 12 weeks. This long delivery time is required because the larger type storage cells are not kept in stock and are manufactured to order from scratch and thus require extended delivery time.

If a device mechanism could be devised for utilizing standard stock batteries with many units in parallel without running into uneven charge and discharge problems, a system could be assembled much more quickly.

The cost of access to such a remote site as Trout Lake can be considerable if a firm schedule has to be maintained. For instance, a flight in or out can sometimes be arranged to be shared with others who are going to the site but if time is not flexible and the trip must be made, a special charter trip may be required both in and out. In the case of the one service visit in March from Edmonton the total travel and living cost exclusive of labour for the visit was in the neighbourhood of $2150.00 as charters were required both ways in and out and on the one trip only a larger aircraft was available. It is obvious that the shipment of hardware to such a remote site should be scheduled if possible to take advantage of the availability of winter roads to reduce the transportation costs.

In the initial installation visit, the delays necessitated a 3 day layover at Fort Simpson that was unscheduled and provided an extra cost item for the installation.

A community hunting trip by the native workmen just prior to the scheduled date of installation meant that little work was done in the two weeks prior to the installation crew's arrival and a number of items such as floors, panel boards and generator shed were not completed, as had been anticipated when the installation arrangements were made. For instance, the sensor platform for the global pyranometer installation was located on the roof of the generator shed and due to the delay in constructing the shed, the platform was not available to mount and connect the sensor until the last minute. The connection was actually made while the departing aircraft was waiting on the runway with the engines running, which left little time to check the monitoring installation before departure.

5.3 OPERATION

The system upon installation and commissioning performed in accordance with the design and was left in a semi-active state as mentioned when the installation crew departed. The generator was not intended to be used during the construction period and was left locked and the automatic start operation was disabled at the control board. In retrospect, a wiser decision would have been to have left the system in complete operational condition as the onsite personnel did activate the generator for the operation of their tools, but the battery charger was not connected. This operation of the unit gave various results to the monitoring system and some out-of-range readings were obtained due to the voltage spikes. Further, during January a heater was apparently plugged into the residential circuits and left on overnight with a subsequent extensive drain on the batteries. The charging system was finally activated by the site superintendent.

The preparation of a detailed operations manual was undertaken to provide as complete a reference as possible for the operators in the remote site. This ended up as a 78 page document when all the hardware specification and operating sheets were included. A total of 10 operations manuals were provided to the housing corporation for their use.

Without an occupant on hand, and with the changes in site superintendents and personnel, no fuel records have been maintained for the operation of the generator, so at this point no data is available with regard to the fuel consumption for the generator unit.

5.4 MONITORING

The monitoring equipment and the method of data transfer via cassette tape has worked reasonably well, despite an unexplained hangup during the month of March. The data stored in the monitoring unit was "milked" (recorder attached and the data transferred to tape cassette from the data logger unit) on this intermittent basis due to the lack of heat within the residence in the winter time and the possibility of malfunction of the cassette tape recorder in the cold conditions. During a "normal operating period" as was expected in the residence once the system was installed, the tape recorder would have been in a heated area and would have functioned without any problem on a continuous basis thus eliminating even the problem of having to "milk" the data.

The original program mounted on the datalogger when installed did not accumulate the daily totals as intended. However, the daily totals were available from the hourly figures that were recorded satisfactorily, and these figures could be extracted from the recorded data.

Modifications were made in the monitoring program during the site visit in March, however, the servicing of the PVPGS required removal of the monitored connections and the reconnections were apparently made incorrectly. As there is no load data being acquired in any event the minor malfunction has not been deemed serious enough to necessitate a service visit, however, once the house is occupied and the monitoring is restarted, a site visit will be necessary to re-establish the proper connections for the monitoring system.

The remoteness of the site highlights the requirement that a monitoring program be well planned and tested before installation, or that more time is allotted for setting up and testing the program by actual operating experience on site once the installation is completed. In this particular case the regular operations could not

be commenced at the time of installation for the complete checkout of the program.

The recorded data of the insolation received on the plane of the array versus that on the horizontal confirms the substantial difference in incident energy due to the geometry of the incident rays. The value of the adjustable tilt angle on the PV array is substantial in improving the array output over a fixed tilt system. The adjustment requires about half an hour for two people to perform, and could be done as little as twice per year for a substantial improvement in output. The successful implementation depends on the interest of the operator and his effort to make the change.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Experience to-date has indicated that the PV Hybrid Power Generating System is an appropriate and reliable source of electrical power for remote residences.

The cost of power output per kilowat hour at this point in time is not definable because actual fuel consumption records are not available for a continued normal operation of the system. As the operation of the unit has been in a standby mode for most of the contract period, the output cannot be considered typical or maximized due to the operation of the regulator equipment when the batteries have been at full charge and power has been dumped.

A review of the solar records indicate that an auxiliary input into the system is indeed necessary at a latitude of 60 degrees north to enable a reasonable output during the winter months.

The adjustable tilt angle of the PV array can produce a significant improvement in the overall output even when varied only two times per year. For an individual homeowner endeavouring to maximize the output of the system, a monthly change would optimize the power available from the solar portion of the system.

Recommendations flowing from the work on the contract are as follows:

1. It would be most advisable to obtain a firm understanding in writing at the outset of any similar project of the hardware ownership and responsibilities and commitments for all the parties concerned. If this is not available as a formal signed agreement at least it should be laid down in writing as understood at the outset by the prime contractor.

2. If negotiations can be finalized with the parties concerned, it is recommended that this PV/Hybrid PGS system be maintained in place for twelve additional months, or at least until June 30th, 1988, with the monitoring in place in order to obtain operational

performance records of the system under normal use. The status should be reviewed and the future of the installation determined by April 30th, 1988, ie. whether or not the system should be maintained on site or moved to another location where grid or community power is not available.

Despite the presence of the community power which is now available, there would be good value in obtaining long term operational experience with this system in place "as is", to confirm its use as a viable alternative to other power sources. The presence of the community power to the other residences in the community will provide a good basis for comparison with regard to usage and reliability of the systems.

If an immediate transfer of ownership is required it is recommended that title be transferred to the NWTHC or CMHC as opposed to the Northwest Territories Department of Public Works and held there until the long term location is finalized in 1988.

3. The installation of the community power provides an excellent opportunity to obtain actual cost data for a comparison between the use of a community power for a small community versus the de-centralized power systems such as the hybrid on each residence. It is recommended that EM&R endeavour to obtain the actual cost data for the community grid installation from Northland Utilities (NWT) Limited along with operating cost data in order that a better assessment will be available of the relative costs of the two power sources.

4. It is recommended that EM&R maintain liaison with the Northwest Territories Housing Corporation and Canada Mortgage and Housing Corporation regarding the use of PV hybrid systems for future projects.

5. When the actual loads have been defined for the residence as now constructed, a rerun of the simulation program should be arranged utilizing the specifications of the installed hardware and load characteristics. This would permit assessment of the correlation between the real life data, the assumed data at the design stage, and the other data that was available at the time of the initial runs. It would also provide an opportunity to validate the model for the simulation program.

7.0 REFERENCES

#1 - R.L. Watts, et al.: "Photovoltaic Product Directory & Buyers Guide 2nd ed."; Van Nostrand Reinhold Company Inc. 1984. pg.18

#2 - Spectral Engineering Inc.: "Overview and Assessment of PV Technical Industry and Market Opportunities"; Report for Ontario Ministry of Energy 1983

#3 - Adkinson and Associates: "Limited Power Low Voltage Photovoltaic for Remote Residences"; National Research Council of Canada Contract SXOSX83-00131

#4 - Adkinson and Associates: Interim Report "PV Hybrid Res.PGS"; contract report to Energy Mines & Resources June, 1986. Contract Serial no.23216-6-6108/D1-SZ

APPENDIX A

Extract from Operation's Manual

OPERATIONS MANUAL

FOR

PHOTOVOLTAIC /HYBRID RESIDENTIAL POWER GENERATING SYSTEM

Installed at:

Staff Residence, (NWTHC)
Trout Lake,
Northwest Territories

Prime Contractor for ENERGY ,MINES, & RESOURCES, CANADA:
Adkinson and Associates,
415 Brian Court,
Pickering, Ontario,
L1W 3H5

Contact: D. Adkinson 416 831-2690

Installation Contractor:
Sun Direct Energy Inc.,
PO Box 136,
Colinton, Alberta,
T0G 0R0

Contact: Ron LaPlace 403 675-2586

Maintenance Agency:
Northwest Territories Housing Corp. (NWTHC)
Box 2100
Yellowknife, NWT
X1A 2P6

Contact: W. Herzog 403 873-7886

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PVPGS OPERATIONS MANUAL

FOR STAFF RESIDENCE, TROUT LAKE, NWT

SECTION 1.0 GENERAL DESCRIPTION

This manual describes the photovoltaic/hybrid power generating system installed in the staff residence at Trout Lake, NWT. It is a combination system utilizing a photovoltaic array to convert sunlight directly to electricity which is then stored in lead acid storage batteries and subsequently converted to normal electrical power through an inverter. Additionally the system has a gasoline powered generator set which is activated automatically to recharge the batteries through a charger unit. The gasoline generator can also be started manually to provide up to 5.5 kilowatts of power directly to the residential circuits if required.

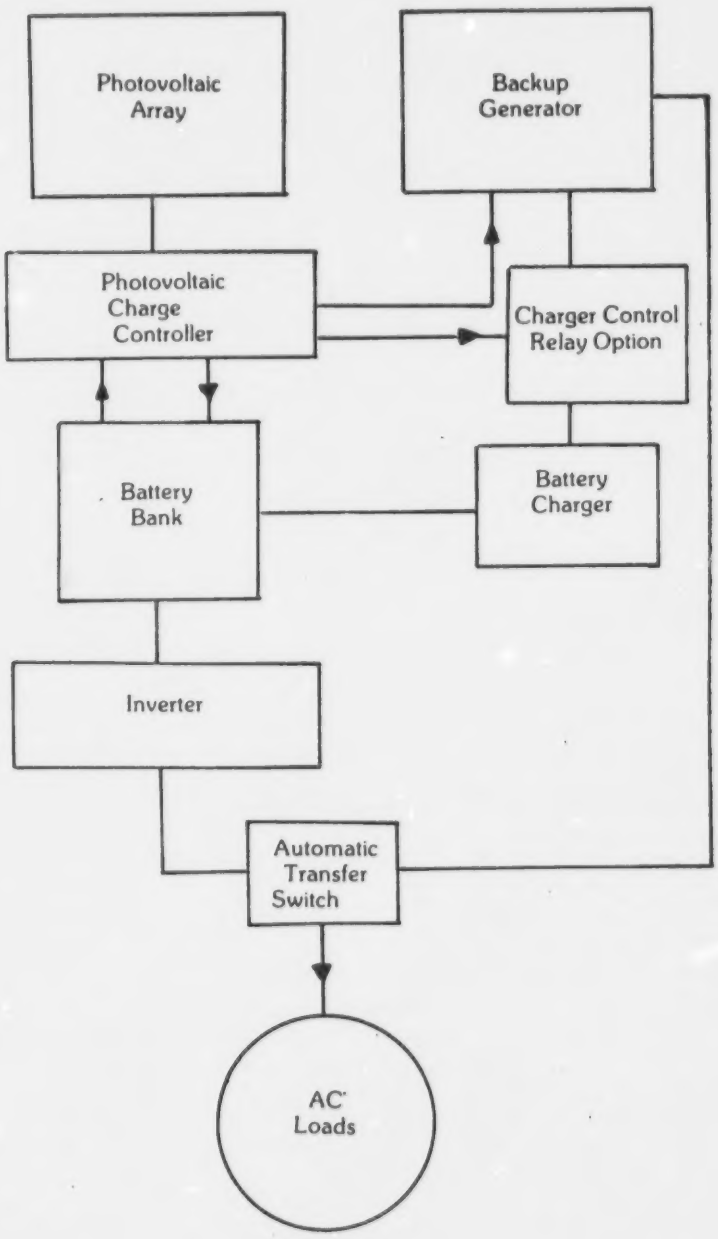
SECTION 1.1 ELECTRICAL OUTPUT

The electrical output of the PVPGS system is 110 volt AC 60 Hz. This is the normal type of household power that is supplied in a conventional electrical grid. All types of normal household appliances and entertainment equipment should operate satisfactorily on this power.

Without the gen set running the total household operating load should not exceed 3000 watts.

With the gen set operating, a total load of approximately 5000 watts continuous or 5500 watts intermittent can be supplied safely.

Note that with the gen set operating, but only when the gen set is running, 220 VAC is also available at the generator and at the AC distribution panel in the home.



"Figure 1"

BLOCK SCHEMATIC OF HYBRID PVPGS COMPONENTS

SECTION 1.2 HARDWARE COMPONENTS

The main elements of the PVPGS are as follows:

a) The Array

This is the externally mounted group of photovoltaic modules which receives the sunlight and converts it to electricity.

b) A Charge Regulator

This component disconnects the array from the batteries when they become fully charged and require no more input. It also prevents the electrical energy leaking from the batteries back to the array when there is no sunlight.

c) The Batteries

The battery storage bank receives the direct current as produced by the array and by the generator powered battery charger, and stores it in an electro-chemical manner for use at times when the sun is not shining.

d) The Inverter

The inverter changes the direct current power from the batteries as stored, into the 110 volt alternating current as required by the household appliances.

e) The Gasoline Genset

The generator "genset" is an auxilliary generator which will supply power to the residential circuits directly and also provide backup power to recharge the batteries when required.

f) Battery Charger

The battery charger receives the power from the generator set and converts it to direct current and feeds it in the appropriate amounts to the batteries for maximum rate of charge and subsequent storage.

g) Control Panel

The control panel contains the switches for isolating the various parts of the system as well as the TRANZAC switching unit which automatically starts the generator when the batteries become discharged. This unit also turns off the inverter when the generator set starts and turns it back on when the generator stops.

h) Monitoring System

The monitoring system is a temporary installation to record the performance of the system and it measures the power, current, voltages, and temperatures, etc. at various parts of the circuit and records it on a cassette tape.

SECTION 1.3 OPERATING DESIGN - OUTPUT & LOAD LIMITATIONS

The system is designed to supply approximately 7.4 kilowatt hours of electrical energy per day through the combination of the photovoltaic system and the generator set.

When running on the inverter only without the generator set running the maximum continuous load should be 3000 watts.

If larger power loads are required the generator set can be started manually and in this operational mode, when the inverter is not running, the maximum power load that can be drawn is 5500 watts. For continuous operation the load should be limited to 5000 watts from the gen set.

The design load is listed on the next page.

ADKINSON AND ASSOCIATES

PROJECT DATE: June 24/86
Staff Res. Trout Lake
NWT LOAD ESTIMATE WORKSHEET FOR SOLAR POWER REQUIREMENTS

	APPLIANCE	NUMBER	WATTS	AV.HRS /day	kWhrs /day	days /wk	kWhrs /wk	Monthly kWhrs	Annual kWhrs
1	Lights ,fluorescent	2	20	4	0.16	7	1.12	4.85	58.2
2	Lights, fluorescent	4	40	1	0.16	7	1.12	4.85	58.2
3	Lights, misc.	2	100	2	0.4	7	2.80	12.13	145.6
4	Radio	2	10	6	0.12	7	0.84	3.64	43.7
5	TV 25 in colour	1	130	3	0.39	5	1.95	8.45	101.4
6	VCR	1	30	3	0.09	5	0.45	1.95	23.4
7	Stereo	1	15	5	0.075	6	0.45	1.95	23.4
8	Refrigerator	1	250	10	2.5	7	17.50	75.83	910.0
9	Radio Telephone	1	10	24	0.24	7	1.68	7.28	87.4
10	Electric clocks	2	4	24	0.192	7	1.34	5.82	69.9
11	Pump, pressure 1/8 hp	0	240	1	0	7	0.00	0.00	0.0
12	Pump, DHW 1/30 hp	0	30	2.5	0	7	0.00	0.00	0.0
13	Sewage heat trace	0	200	1	0	7	0.00	0.00	0.0
14	Can Opener	1	100	0.01	0.001	5	0.01	0.02	0.3
15	Microwave	1	1200	1	1.2	5	6.00	26.00	312.0
16	Food Processor	1	1200	0.1	0.12	5	0.60	2.60	31.2
17	Exhaust fans	0	44	0.25	0	7	0.00	0.00	0.0
18	Iron	1	1500	0.05	0.075	7	0.53	2.28	27.3
19	Dryer(hair)	1	1500	0.5	0.75	3	2.25	9.75	117.0
20	Vacuum	1	750	0.5	0.375	5	1.88	8.13	97.5
21	Stove fan	1	44	24	1.056	7	7.39	32.03	384.4
22	Fire alarm	0	1	24	0	7	0.00	0.00	0.0
23	Shaver	1	15	0.25	0.004	7	0.03	0.11	1.4
24	Washer Clothes	1	900	0.5	0.45	7	3.15	13.65	163.8
25	Misc. Tools	1	200	0.5	0.1	7	0.70	3.03	36.4
26					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
					0		0.00	0.00	0.0
	MAXIMUM DAILY LOAD				8.458				
	Total kWhrs per week						51.78		
	Total kWhrs per month							224.37	
	Total kWhrs per year								2692.4
	Average daily load				7.40				

DESIGN LOAD FOR PVPGS AT TROUT LAKE PROJECT
FIGURE 2

SECTION 1.4 CONTROLS

There are 3 basic units in the control system and these are:

a) battery charge regulator

b) TRANZAC transfer switch

c) gen wizard - generator starter

1.4.1 Battery Charge Regulator

The battery charge regulator has the function of disconnecting the solar array from the system when the battery storage is full and additional power from the array would only tend to boil off the electrolyte in the battery. When the battery reaches it's full state of charge the charge regulator will disconnect the array from the battery.

It also disconnects the array from the storage unit at night to prevent back current leakage through the array when it is not charging.

1.4.2 TRANZAC Transfer Switch

The TRANZAC transfer switch will normally operate automatically when the battery storage level is low and needs recharging, however it can be operated manually. (See Section 3.3) Its function is to detect the need for generator charging, start up the generator, shut down the inverter, and then connect the generator charger set to the household circuits in place of the inverter. When the battery is sufficiently charged it will shut down the generator set, start up the inverter and connect the inverter to the household circuit after disconnecting the generator set.

1.4.3 Gen Wizard Control

The gen wizard control is the unit that actually sends the signal to the generator to start it and signals if there is any problem in the operation of the generator. Its operation is normally controlled by the TRANZAC switch and is completely automatic in normal operation. It does have override and adjustment controls which normally will not require attention by the occupant.

SECTION 2.0 OPERATIONAL MODES

2.1 Summary of Normal Control Positions

A chart showing the normal position of all the switches and the normal status of all the indicator lights for the various operational modes is provided at the end of this section (page 10).

2.2 Normal Use (Non Charging Mode)

This is the normal night-time use when neither the array nor the generator set is putting power into the battery but the system is delivering power to the house through the inverter. In this mode everything is completely automatic.

2.3 Solar Charging

In this mode the system is being charged from the sunlight coming through the array and providing power to be stored in the batteries. Power will be supplied to the household circuits during this time automatically through the inverter (providing the genset is not running) and the operation is completely automatic.

2.4 Genset Charging

In this mode the generator set is running and providing power to the system. This can occur whether the solar array is charging or not. During this operation the inverter unit is disconnected and the power to the house circuits is being delivered directly from the generator set and no power is coming from the batteries. When the power level of stored energy in the batteries gets low, the genset wil be started automatically and will run until the batteries are approximately 70% charged and then will automatically stop. This starting and stopping will be automatic and does not require attention during

this cycle.

2.5 High Load Use - Genset Operating

This is the mode that would be used when a high powered demand is required, ie. in excess of 3000 watts and the genset has been manually started. In this mode up to 5500 watts of power can be obtained through the normal household circuits providing the genset is operating. Any surplus power that is not used in the residential load circuits will be delivered through the battery charger to the batteries and stored for future use. The genset will shut down automatically if the load can be handled by the inverter and the batteries reach their "charged" level.

PV HYBRID POWER GENERATING SYSTEM - TROUT LAKE STAFF RESIDENCE
NORMAL CONTROL POSITIONS FOR VARIOUS MODES OF OPERATION

OPERATIONAL MODE	SWITCH SETTINGS			
	NORMAL USE NON CHARGING	SOLAR CHARGING	GENSET CHARGING AUTOMATIC	HIGH LOAD USE GENSET OPERATING MANUAL
CONTROL EQUIPMENT				
TRANZAC				
Source Selector	Auto	Auto	Auto	Auto
Control Status	Local	Local	Local	Local
Display Selector	1-2-3	1-2-3	1-2-3	1-2-3
Alert 1 Light	Off	Off	On	Off
Alert 2 Light	Off	Off	Off	Off/On
INVERTER				
Switch 1	On	On	On	On
Switch 2	On	On	On	On
Orange Light	On	On	Off	Off
CONTROL ENCLOSURE				
GEN WIZARD				
Control Mode Switch	Autostart	Autostart	Autostart	Manual
Crank Time	--	--	--	--
Genset Selector Switch	Main	Main	Main	Main
GS Failure Light	Off	Off	Off	Off
GS Running Light	Off	Off	On	On
BATTERY VOLTAGE REGULATOR				
Charging When Lit Light	Off/On	On	Off/On	Off/On
DC SOURCE CENTRE				
Master Switch	On	On	On	On
PV ARRAY DISCONNECT SWITCH				
Switch	On	On	On	On
BATTERY CHARGER				
On/Off Switch	On	On	On	On
Light	Off	Off	On	On
Meter	0	0	+ >0	+ >0
GENERATOR				
On/Off Key Engine Switch	On	On	On	On
Oil Lamp	Off	Off	Off	Off
Auto Throttle Switch	Off	Off	Off	Off
Remote Control Switch	Off	Off	Off	Off
Pilot Lamp (Green)	Off	Off	On	On
Circuit Breaker Switch	On	On	On	On
Water Lamp	Off	Off	Off	Off

NOTE: OFF/ON indicates either setting possible in normal operation.

"Figure 3"

Ident.No.: 123 PV Hybrid Residential Date: Oct. 31/86

GENERAL:

Location:	Trout Lake NWT	Latitude & Longitude	60'N 118' W appr
Owner:	NWTHC	Elevation:	
Identification:	Trout Lake Staff Residence	Solar Data Source:	Fort Smith
Type of Load:	Residential	Solar Data Site:	AES
Avge Daily Load AH:		Operating Months:	12
Avge Daily Load Whr	7.4 kWh	Min. Solar Month:	Dec
System Voltage:	24/110	Avge Daily Rad.MJ/m2:	.0033
		Equivalent Sun Hrs:	.915

PV ARRAY:

Array Rating Wp:	672	Quantity of Modules:	16
Module Model:	SX 42	Array O/put Voltage:	24
Module W x L xD :	445 x 965 x 54 mm	Module Rating Wp:	42
Array Area m2 :	6.87	Module Output Amps:	2.6
Array Incl. Deg.:	60	Series/Parallel:	2 X 8
Array Orient.Deg.:	180	Manufacturer:	Lenbrook/Solarex

REGULATOR/CONTROLLER

Regulator Type:	Series	Manufacturer:	Photron
Model No.:	BVR-30TC	Capacity Amps:	30
Blocking Diode Inc.?	no	No. Required:	1
Location:	Control Panel	Comments:	see Sec.3.6

TRANSFER SWITCH:

Tranzac Control Switch		Manufacturer:	Photron
Model:	PT2 24/30 24 UID	Srial No.:	05158601

BATTERIES:

General Description:	PbA deep cycle			Days No Sun Storage:	3 -4		
Manufacturer:	GNB			Min. Cell Temp.C:	10		
Electrical:							
Capacity @25'C:	1325	Amp.Hrs.		Cell Model No.:	NAL860		
Discharge Rate:	100	Hours		No. Cells Req'd.:	12		
In/out Efficiency:	80	%					
Physical:							
Cell width mm.:	369	Length:	187	Height:	562	Weight Kg:	80
Battery Width mm.:	738	Length:	1122	Height:	562	Weight Kg:	960

Rack Location: Matting Model No.: 804-167-585

POWER CONDITIONER

General Description:	24V DC/110V AC Inverter -Series 20				
Model No.:	PF 24/3000	Eff.@ 95%:	90	Manufacturer:	Vanner
Output Volts:	110VDC	@ 50%:	93	Location:	Control panel
Rated Capacity:	3000 W	@ 10%:	75		
Surge Capacity:	4800W	Time min.:	10		see Sec. 3.5
Physical:					
Width cm.:	39.37	Height:	15.675		
Length cm.:	31.75	Wt. Kg.:	23.18		

SPECIFICATION SHEET FOR PV SYSTEM

FIGURE 4

PHOTOVOLTAIC MODULES

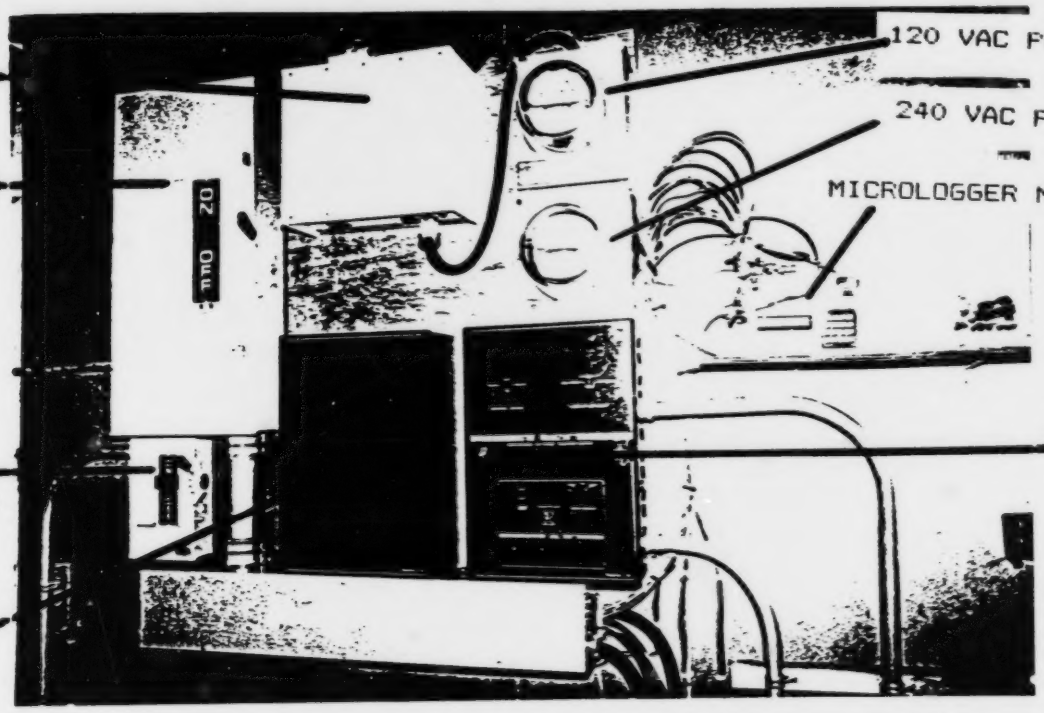
MODEL #AQ0816000 TYPE SX42 MANUFACTURED BY SOLAREX CORPORATION NOCT STATED AT 49 DEGREES C

	VOC	ISC	PNOCT	INOCT	VNOCT	PNOM STC	PMIN 25'C	ISC 49'C
EAST PANEL - TOP DOWN								
RK86E290122TF	20.6	2.91	40.8	2.7	15.1	44.9	42.0	2.96
RK86F170013TF	20.7	2.95	41.2	2.71	15.2	45.4	42.0	3.0
RK86E290145TF	20.8	2.93	41.4	2.72	15.2	45.5	42.0	2.98
RK86F170029TF	20.9	2.99	42.2	2.81	15.0	46.4	42.0	3.04
RK86F160196TF	20.8	2.93	41.2	2.72	15.2	45.4	42.0	2.98
RK86F170025TF	20.7	2.93	40.6	2.72	14.9	44.7	42.0	2.98
CENTRE PANEL								
RK86F170016TF	20.7	2.90	40.2	2.67	15.0	44.2	42.0	2.96
RK86F160199TF	20.8	2.92	40.9	2.72	15.0	45.0	42.0	2.98
RK86F170018TF	20.8	2.91	40.6	2.67	15.2	44.7	42.0	2.97
RK86F170037TF	20.1	2.94	39.1	2.72	14.4	43.3	42.0	3.00
RK86F160197TF	20.7	2.98	41.0	2.78	14.9	45.8	42.0	3.03
RK86F170001TF	20.8	2.93	41.6	2.74	15.2	45.8	42.0	2.98
WEST PANEL - TOP								
RK86F16020ITF	20.8	2.94	41.5	2.7	15.4	45.7	42.0	3.0
RK86F170038TF	20.3	2.93	39.8	2.75	14.5	44	42	2.98
RK86F170015TF	20.7	2.95	41.3	2.72	15.2	45.5	42	3.0
RK86F170010TF	20.8	2.97	41.5	2.77	15.0	45.7	42	3.02

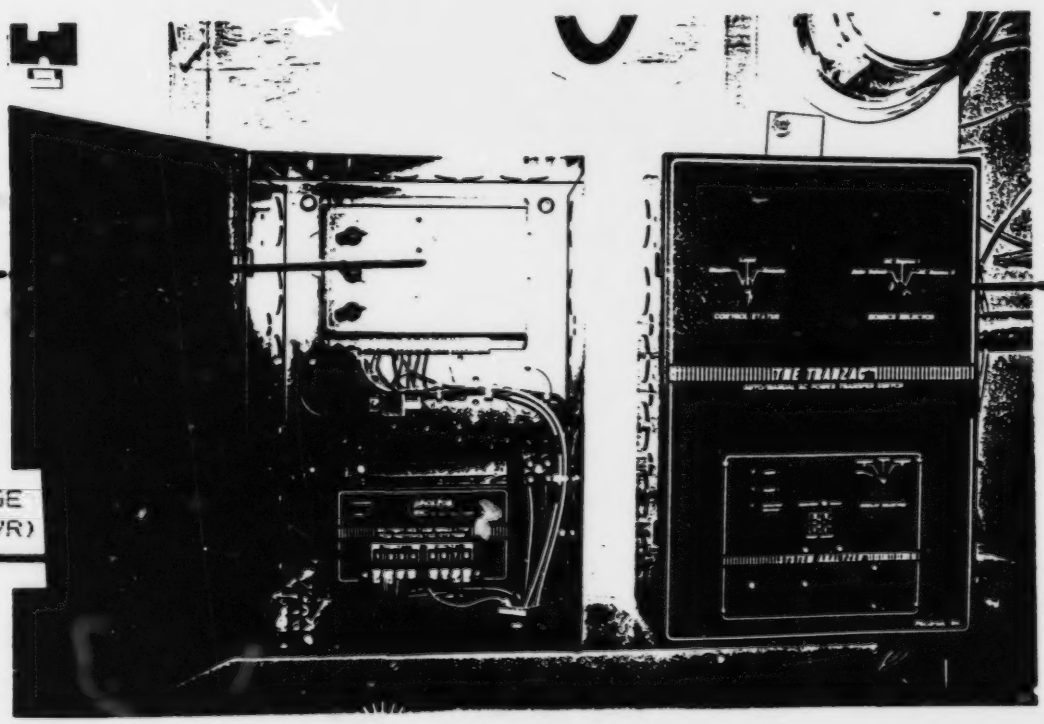
LISTING OF PV MODULE LABEL DATA

"FIGURE 5"

OVERALL VIEW OF CONTROL PANEL



CLOSE-UP OF CONTROL ENCLOSURE



"FIGURE 6"

SECTION 3.0 DETAILED HARDWARE COMPONENTS DESCRIPTION

SECTION 3.1 ARRAY

The solar array consists of 16 photovoltaic modules manufactured by Solarex Corporation Model #SX42. These modules are wired in the configuration to produce 24 volts nominal output. They are wired two in series and 8 in parallel. They are mounted on a ground rack and should be kept clear of snow and ice should it build up during the winter time. Any snow or ice on the module surface will prevent a proper output even when the sun shines. It is important that the array of PV modules does not get shadowed either completely or partly during the normal operation. The output will be seriously affected if this occurs.

The faces of the PV modules are tempered glass and are reasonably resistent to impact by hail etc. but normal precautions should be taken with regard to vandalism and hardballs,? etc.

SECTION 3.2 STORAGE

The electrical power produced by the system is stored in electrochemical storage batteries which are located inside the control room. The battery consists of 12 2 volt cells model GNB-NAL860 which are wired in series to produce 24 volt output. They are described on the literature enclosed and they must be protected from children or unauthorized personnel. The maintenance instructions are simple and are described under Section 4.0. The GNB serial number for this installation is T20977.

These cells are described as deep discharge lead acid antimony cells and have a specific gravity of 1.300 at 25 degree C (77 degrees fahrenheit). Their nominal storage capacity when discharged over a period of 4 days or 96 hours, is approximately 1325 amp hours. This results in a storage capacity of 1325 x 24 volts or 31.8 kilowatt hours of energy. Not all of this is usable however as the batteries should never be discharged below

9/86 T20977

12 CELL NAL-860

TYPE COMMUNICATIONS SERVICE

ASSEMBLED TWO ROWS

GNB Batteries (Canada) Inc.

MATERIAL LIST

APPROVED _____

DATE 8/19/86

BY d.b.

LINE NO.	ITEM	MAT'L	PART NO	DRAWING NO	REV	NO PER BATTERY	TOTAL
	ANTIMONY LEAD CELLS NAL-860 c/w PRE-VENTS		M01-183781			12	
	EACH CELL TO BE COMPLETE WITH THE FOLLOWING STAINLESS STEEL HARDWARE:						
	TERMINAL BOLT,S.S. 5/16-18 X 2	1/4"	W02-168756-008				
	TERMINAL NUT,S.S. 5/16-18		W06-168756-102				
	TERMINAL WASHER,S.S. 1/16 THK		W03-168756-202				
	INTERCELL CONNECTORS		L02-168188-003	168188B		10	
	INTER-ROW CONNECTOR		L02-168188-001	168188B		1	
	TERMINAL CABLE CONNECTOR		L06-086075-144-4/0			2	
	LUG, COP.L.P.	2	L07-041560				
	CABLE, NO. 4/0	149	L04-085038				
	NAMEPLATE		R01-170017			1	
	SET OF CELL NUMERALS		R01-169403-001			1	
	NO-OXIDE GREASE		X14-076001			1	
	HYDROMETER		Z02-001305			1	
	HYDROMETER HOLDER		Z02-001408			1	
	THERMOMETER		Z03-000758			1	
	POLYETHYLENE MATTING		S04-167585-049	167585A		3	
	DRAWING			057795B		2	
	DRAWING			183782A		2	
	MATERIAL LIST			M16-002631		2	
	INSTRUCTIONS			GB-3384		2	

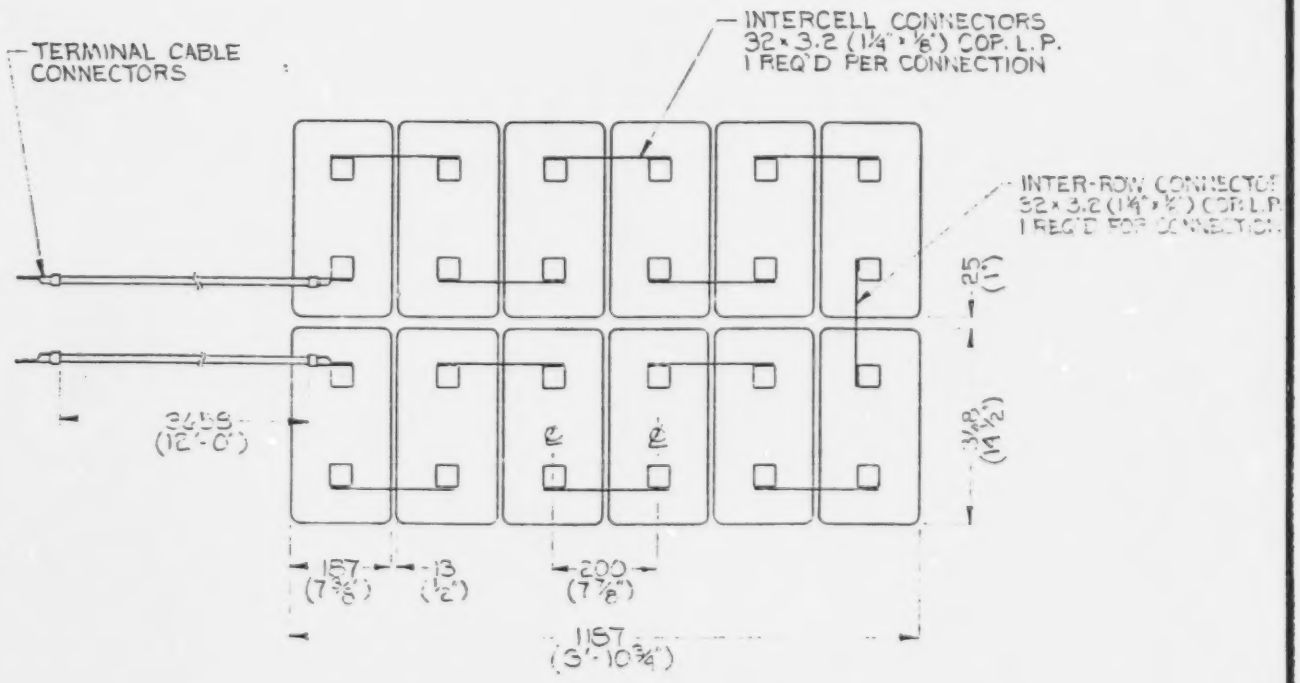
CAP. 860 AH AT 8 HR RATE CHG START _____ AMPS. FIN. _____ AMPS. SP. GR. _____

GNB Batteries GNB

REVISION									
DATE									

ML-002 BATT. SIZE 12 CELL NAL-860

B/M M16-002631



FOR COMMUNICATION SERVICE

ISSUE	DATE	REVISION

TITLE
WIRING DIAGRAM FOR
12 CELL NAL/NCL-84.0

GNB has proprietary rights in this material

Tolerances:

GNB Batteries (Canada) Inc.

GNB Batteries

DRAWING NO. 182782A

DR. A.P. CH.

DATE: AUG 30/84

SCALE:

20% of their capacity. This capacity is also reduced if the temperature of the batteries drops below 25 degrees celsius (77 degrees fahrenheit) and at 0 degrees celsius the capacity would be reduced to about 70% of that at 25 degrees celsius.

While these are special cells they should be checked for low electrolyte levels and specific gravity measurements should be taken twice per year.

SECTION 3.3 TRANZAC

The two switches at the top of the unit should be left in the settings as follows:

For the control status - "local"
For the source selector - "auto select".

3.3.1 Control Status Switch

This switch should normally be in the "local" mode setting.

The "local" setting is the normal operational setting and the unit will normally be left in this configuration.

If at any time work is to be done inside the TRANZAC transfer switch (should be done by an authorized electrician) the control status switch should be selected to the "disable setting". This is a safety feature and disables the interior of the TRANZAC switch.

The "remote" setting is used only if an optional remote display switch is included in the system which is not the case on this installation. For this installation the remote setting is not applicable.

3.3.2 Source Selector Switch

This switch will normally be left in the "auto select" setting.

photron inc.

TRANZAC™ TRANSFER SWITCHES
Installation Recommendations

!!!IMPORTANT!!!

PLEASE READ THESE RECOMMENDATIONS CAREFULLY BEFORE ATTEMPTING TO INSTALL OR OTHERWISE OPERATE THIS PHOTRON PRODUCT.

!!!WARNING!!!

ELECTRICITY (EVEN LOW VOLTAGE ELECTRICITY) CAN BE VERY DANGEROUS. PHOTRON, INC. RECOMMENDS THAT ALL ELECTRICAL INSTALLATIONS - INCLUDING THE INSTALLATION OF THIS PRODUCT - BE PERFORMED ONLY BY LICENSED OR PROPERLY QUALIFIED INDIVIDUALS AND IN STRICT ACCORDANCE WITH APPLICABLE BUILDING AND ELECTRICAL CODES.

1.0 PRODUCT DESCRIPTION

The TRANZAC™ Family of AC Power Transfer Switches are the world's most advanced devices of their kind. Though they can serve numerous discrete functions depending upon the actual model selected, their basic function is the same as that of any AC transfer switch: to allow a given AC load(s) to receive a supply of power from only one AC power source at a time where there are actually two different (out of phase) AC sources available. But of phase AC sources (such as an inverter and an engine generator for example) must always be kept separated electrically as direct interconnection results in catastrophic device destruction.

The TRANZAC is a step beyond other transfer switch designs because it can be used as either an Automatic or Manual Transfer Switch, is both remote controllable, and programmable, and allows for proper "warming up" of the secondary or "back-up" AC power source (when in the automatic mode) before connecting it to the load. (Critical where engine generators are concerned.) For further information on TRANZAC operation and features refer to section #5.0 and #6.0 of this document.

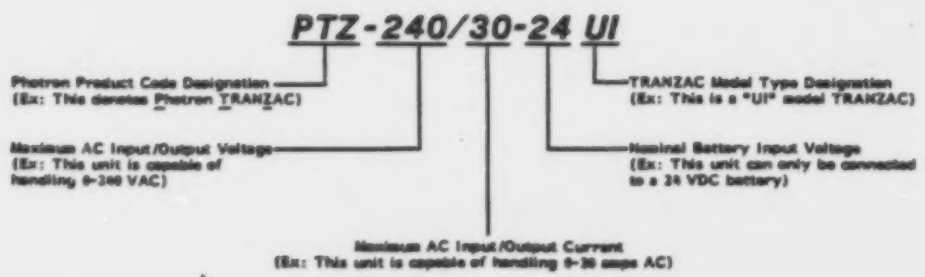
Because these advanced transfer switches have so many different features and hence potential functions, it is extremely important that users become thoroughly familiar with this document in order to obtain maximum benefit and safe operation from their new Photron TRANZAC.

!!!IMPORTANT!!!

These installation recommendations cover all 4 of the different TRANZAC models. Because different models have different operational features and hence different hook-up details, etc. - the following installation and use information is arranged by model type. THEREFORE, YOU NEED ONLY EMPLOY THAT INFORMATION WHICH APPLIES TO THE PARTICULAR MODEL TYPE YOU ARE INSTALLING.

There are 4 model types: Standard, "SH", "UI", and "UI Digital". To identify your model type, refer to the product ID label located on the inside of the enclosure's front door. The model type can be identified by reading the last segment of the model number. (E.g., a PTZ-240/30-24UI is a "UI" model, etc.) Note - Standard units carry no additional model designation (e.g., a PTZ-240/30-24 is a "Standard" unit). See Figure 1 below for assistance in understanding your TRANZAC's model #:

FIGURE 1: Sample ID Label Model # Code Breakdown


PTZ-240/30-24 UI
Photron Product Code Designation
(Ex: This denotes Photron TRANZAC)
Maximum AC Input/Output Voltage
(Ex: This unit is capable of handling, 0-240 VAC)
Maximum AC Input/Output Current
(Ex: This unit is capable of handling 0-30 amps AC)
Nominal Battery Input Voltage
(Ex: This unit can only be connected to a 24 VDC battery)
TRANZAC Model Type Designation
(Ex: This is a "UI" model TRANZAC)

2.0 LOCATION

Mount the TRANZAC in an indoor area that is protected from wind, rain, excessive dust, moisture and heat as you would a standard household radio or TV.

The TRANZAC must be mounted in a vertical position: the 4 holes in the extreme corners of the enclosure's back are provided for this purpose.

Ideally the TRANZAC should be located near the power system elements it is to control - but never confined within a sealed battery enclosure where hydrogen gas from normal battery charging might accumulate.

TRANZAC terminals #1 - #8 will accept up to #4 gauge wire, while #9 - #H will accept up to #10 gauge wire. If larger gauge wire is used, a down converter to these maximum sizes is required. (This can be simply accomplished thru the use of a common "wire or twist nut", etc.) Be sure to anchor all wires that you connect to the TRANZAC terminal strip within one foot of the unit so that no stress is placed upon the terminal strip itself. (Clamping strain reliefs installed in the knockout holes are ideal for this.)

Where the TRANZAC is to be mounted out of the path of normal daily travel, use of Photron's optional TRANZAC Remote Source Selector Switch Assembly (#PTZ-1) is suggested. (This connects simply to the TRANZAC terminal strip and allows duplication of the TRANZAC's Selector Switch functions at any remote locale the user may desire.)

Where the TRANZAC is to be mounted in the vicinity of non-qualified personnel or users, padlocking of the enclosure's front door through the locking tab provided is strongly recommended.

3.0 WIRING

Note: When making wire connections to the TRANZAC be sure that the wires you are handling are fully de-energized and that the "Control Status" switch is set to the "DISABLE" position. Failure to do so may cause severe bodily harm or permanent damage to the TRANZAC, voiding its warranty (not to mention your fingers!).

All connections to the TRANZAC terminal strip should be made with stranded copper wire. The actual size of the wire to be utilized depends upon the current rating of the TRANZAC model you are installing, (as designated by the size of the units internal load fuse), and the overall length of the wiring run to be made. Table 1 below will aid installers in wire size selection:

TABLE I: Minimum Copper Wire Sizes (AWG) For Use In TRANZAC Hook-up (1)

TRANZAC Terminal #	Size of Internal Load Fuses (in Amps)	Total Distance Between System Component to be Connected and TRANZAC Terminal Strip			
		0-75 ft.	76-125 ft.	126-200 ft.	201-325 ft.
1 - 8	0 - 30	#10	# 8	# 6	# 4
"	35 - 60	6	4	2	0
"	65 - 100	4	2	0	00
9,10,A	0 - 30	#10	# 8	# 6	# 4
"	35 - 60	"	"	"	"
"	65 - 100	"	"	"	"
11	0 - 30	#22	#22	#22	#22
"	35 - 60	"	"	"	"
"	65 - 100	"	"	"	"
12 (2)	0 - 30	#22	#22	#22	#22
"	35 - 60	22	20	18	16
"	65 - 100	"	"	"	"
B - G	0 - 30	#22	#20	#18	#16
"	35 - 60	"	"	"	"
"	65 - 100	"	"	"	"
H	0 - 30	N/A	N/A	N/A	N/A
"	35 - 60	"	"	"	"
"	65 - 100	"	"	"	"

NOTES: (1) This table assumes the use of 90 °C rated wire insulation (e.g., type "THHN" or equivalent). Wire sizes given are nominal values, site specific conditions may dictate significant variances.

(2) For all 24VDC TRANZACS, terminal #12 may utilize #22 ga. wire for runs up to 325 feet.

Hook-up the TRANZAC per the instructions mounted on the inside of the enclosure's front door. Always ground the metallic TRANZAC enclosure with a suitably sized copper wire (#10 for up to 30 amp units, #8 for 35 - 100 amp units). Always ensure that proper overcurrent protection (fuses or circuit breakers, etc.) exists for TRANZAC wire runs at the original point where they are connected to sources of power. [For example, terminals #5 and #6 @ AC Source II; #7 and #8 @ AC Source I; #10 @ the system's positive (+) battery terminal or bus bar, etc. NOTE: The wires that connect to Terminals #10, 11, 12, and B should be fused at values no greater than 2 amps. Terminal #A must be fused at no greater than 30 amps before it leaves the TRANZAC enclosure.]

!!!WARNING!!!

When wiring the TRANZAC, be careful to ensure that all of the wires from a given incoming AC Source or those outgoing to a given AC Load pass through the same enclosure knockout holes. Never separate the wires from one of the above points and allow them to pass through different holes in the enclosure. Failure to observe this warning may cause dangerous induced currents to flow in the TRANZAC enclosure and hence throughout your entire grounding system!

4.0 HOOK-UP DETAILS

Connections to the TRANZAC'S numbered terminal strip (located inside the enclosure see Fig. 6B) can be made in any order desired, however for safety's sake always place the "Control Status" switch to the "Disable" position before the start of any wiring to the unit.

All TRANZAC'S are equipped with a 20 position terminal strip numbered 1 - 12 and A - H. The actual terminals you will need to utilize depend upon the TRANZAC model you are installing, and the features of that model which you intend to employ. The "Hook-up and Control Detail" sticker located on the inside of the enclosure door will quickly instruct you as to which terminals to wire, etc. A description of each terminal's functions follows in order to aid you in making hook-up decisions (note that "T" stands for "terminal"):

4.1 Terminals #1, 2, and 3 --- ALL MODELS

These are the AC output terminals which connect to your AC circuit breaker box (load center or load, etc.). T#1 is AC HOT (line 1), T#2 is AC HOT (line 2), and T#3 is the AC NEUTRAL. The output voltage between line 1 (T#1) or line 2 (T#2) and neutral (T#3) is always equal to ±120 VAC. Alternately, the output voltage between line 1 (T#1) and line 2 (T#2) is always equal to ±240 VAC (assuming the input source is 120/240 VAC split phase).

T#3 is often used as a convenient point at which to connect the system's AC Neutral to the system's "grounding electrode" (ground rod, cold water pipe, or other suitable grounding means).

4.2 Terminal #4 --- ALL MODELS

This terminal is the point at which both of the incoming AC SOURCE NEUTRALS (from AC Source I and II) are connected so that the entire AC system will have a conveniently located common neutral.

4.3 Terminals #5 and #6 --- ALL MODELS

These are the AC input terminals for the incoming wires from AC SOURCE II. T#5 is for AC HOT (line 1), while T#6 is for AC HOT (line 2). "AC SOURCE II" is defined as the 'back-up' or 'secondary' source of AC power for your system. In other words, it is typically the AC source (such as an engine generator) which you use for the least amount of actual time.

4.4 Terminals #7 and #8 --- ALL MODELS

These are the AC input terminals for the incoming wires from AC SOURCE I. T#7 is for AC HOT (line 1), while T#8 is for AC HOT (line 2). "AC Source I" is defined as the 'main' or 'primary' source of AC power for your system. In other words, it is typically the AC source (such as an inverter) which you use for the longest period of time.

4.5 SPECIAL NOTICE --- ALL MODELS

4.5.1 The 35 - 100 amp, 120 VAC TRANZAC'S (model #PTZ-120/100-XX, etc.) are 120 VAC only units and therefore do not utilize T#2, #6, or #8.

4.5.2 Under no circumstances should T#1 and #2 ever be connected together (paralleled).

4.5.3 When installing a 120/240 VAC (3 wire) system where one of the AC Sources is capable of 120 VAC (2 wire) only operation, always connect the single AC HOT lead from the 120 VAC only source to a "line 1" position. (I.e., for AC Source I use T#7, or for AC Source II use T#5.) If the 120 VAC only source is to power all of the 120 volt loads that the other 120/240 source powers, always jumper the 120 VAC only source "line 1" position to the respective source's "line 2" position. [Example: a typical home is wired for 120/240 VAC operation. Suppose you had a 120 VAC only (2 wire) inverter as AC Source I, a 120/240 VAC (3 wire) engine generator as AC Source II, and wanted to wire the home so that no matter which Source was in use, all of the home's 120 VAC loads were always capable of being energized. Simply connect the single 120 VAC HOT lead from the inverter to T#7 and T#8. Then connect one of the generator's two AC HOT leads to T#5, and the other to T#6.]

4.5.4 For further information on hook-up details of this nature see Section #7.0 below.

4.6 Terminals #9 and #10 --- ALL MODELS

These are the DC CONTROL INPUT terminals for all TRANZACS. T#9 is for connection to your system's battery negative (-), T#10 is for connection to battery positive (+). (Note: TRANZAC models "UI" and "UI Digital" utilize these terminals to measure the voltage, and hence state of charge, of your system's battery storage bank.) Always be sure that your system's nominal battery voltage is the same as that for which your TRANZAC was designed prior to wiring up these terminals! (See Section #1.0 for details.)

4.7 Terminals #11 and #12 --- ALL MODELS EXCEPT "UI" AND "UI DIGITAL"

These are the REMOTE CONTROL INPUT terminals for use with Photron's optional TRANZAC Remote Source Selector Switch Assembly (order #PTZ-1). The remote selector switch allows you to duplicate the TRANZAC'S door mounted "Source Selector" switch functions to any remote location you desire (when the "Control Status" switch is set to the "Remote" position). T#11 connects to PTZ-1 remote switch lead #P; while T#12 connects to PTZ-1 remote switch lead #M.

Basically, the PTZ-1 remote switch lead #P is used to feed in an AC Source II AC HOT signal to T#11, while switch lead #M is used to feed in system battery positive (+) to T#12. When the AC signal is fed into T#11 (with the "Control Status" switch set to the "Remote" position) the transfer switch will activate after the preset "warm-up period" has elapsed. (This is the "Auto Select" mode, see item #5.2 below.) Alternately, should system battery positive (+) be fed into T#12 - the transfer switch will activate at once (this is "Manual Select" mode - no warm-up time applies).

The remote control feature is especially handy for use in home power systems where the back-up AC source (generators, etc.) is physically isolated from the house (to avoid noise and fumes, etc.) as manual transfers or operational changes from manual to auto modes can be made without ever having to leave the house!

4.8 Terminal #A --- MODELS SH, UI and UI DIGITAL ONLY

This is the AC OUTPUT SIGNAL/supply terminal that is used to convert combination inverter/battery charger products into their battery charger mode. T#A provides up to 30 amps of AC HOT (line 1) current from AC Source II after the preset "warm-up period" has elapsed. To employ this function, simply connect the AC HOT input lead from your combination inverter/battery charger unit to T#A, and its AC Neutral lead to T#3. (Refer to respective unit manufacturer's product instructions.)

Note: AC current drawn from this terminal must never exceed 30 amps @ 120 VAC. Always properly fuse the wire you connect to this terminal at no greater than 30 amps before it leaves the TRANZAC enclosure.

4.9 Terminals #B and #C --- MODELS UI and UI DIGITAL ONLY

These are the REMOTE GENERATOR START contact terminals. They are available for use with properly designed 2-wire starting gen sets only. These terminals are "open" until the system's battery voltage reaches the preset low level (factory set @ 1.83 volts per cell or 11.0 volts for a nominal 12 volt battery, or 22.0 volts for a nominal 24 volt battery, etc.), at which point they become "closed" (shorted) via an internal control switch (relay) which in turn starts the gen set. When the system's battery voltage reaches 2.5 VPC or 15.0 volts for a nominal 12 volt battery, or 30.0 volts for a nominal 24 volt battery, etc. (standard factory setting) the control switch re-opens and hence disconnects the terminals from one another thereby "stopping" the gen set. These voltage levels are user adjustable on the "UI Digital" models only (see step #6.2.2.3 below). Regular "UI" models can only be adjusted at the factory by trained technicians.

To use these terminals simply connect one gen set remote start lead to T#B and the other to T#C. It is critical that you observe the following notes however:

4.9.1 There is no voltage applied to these terminals internally (the internal relay contacts are "dry").

4.9.2 These terminals can be employed only with special "2 wire remote start" design gen sets that feature an automatic choke system. If unsure about your particular gen set type consult the unit's installation and operation manual or Photron's Engineering Dept. for assistance. (For non-2-wire remote start gen sets Photron manufactures the "Gen-Wizard" a gen set start adapter and controller that will properly adapt most electric start generators for 2-wire remote control operation.) Always ensure that the remote start leads from your gen set are properly fused at 2 amps or less before connecting them to the TRANZAC.

4.9.3 The electronic brain within the TRANZAC that measures system battery voltage always applies a time delay to the (low level) output signal that tells the gen set to start. On UI models the delay period is factory fixed at ±110 seconds. On UI Digital models the delay period is user adjustable from 6 seconds to 8 minutes max. This time delay signal feature helps prevent against erroneous gen set starts due to momentary dips in battery voltage caused by power surges from inverters, etc. (There is no time delay applied to the high level output signal responsible for stopping the gen set.)

4.9.4 It should be noted that there are other uses for T#B and #C if auto gen set starting is not to be employed. The most common of these is to use them to trigger a remote alarm or add/shed loads (AC or DC) in response to battery condition as desired. [If loads to be controlled are to exceed 2 amps @ 120 VAC (resistive), utilize an external relay or contactor whose coil is controlled by T#B and #C, to handle the load, etc.]

4.10 Terminals #D and #E; #F and #G --- MODEL UI DIGITAL ONLY

These are the REMOTE DC CURRENT SHUNT SIGNAL INPUT terminals. The signal fed into T#D and #E is read by the TRANZAC'S "System Analyzer" digital display when the door mounted "Display Selector" switch is set on the "Current A" position. Likewise the signal fed into T#F and #G is read when the same switch is placed on the "Current B" position.

CAUTION: When using the UI Digital's current readout feature you must employ precision metering shunts (available from Photron - see Fig. 4A) which are to be installed only in the Negative (-) DC line of the circuit you wish to monitor. Installation of shunts in the Positive (+) DC line will damage the UI Digital's System Analyzer circuit and void its warranty. NEVER INSTALL SHUNTS IN AN AC LINE - YOUR UI DIGITAL IS NOT CAPABLE OF READING AC CURRENT!

Observe the following procedures when selecting and installing current shunts for use with the UI Digital:

4.10.1 The display reads the shunt(s) signal directly to a maximum of 3 digits. (Maximum readout is "99.9".) Therefore to employ the display's current reading directly use of a "100 amp/100 millivolt" rated shunt is required. With this shunt the maximum amount of current that can be read is 99.9 amps. Higher levels of current with this shunt will cause the display to "overrange". (I.e., for 125.6 amps of current flowing, the display would drop the "1" and read only "25.6", etc.) Avoid continuously overloading a shunt in this manner, damage to the shunt may occur.

4.10.2 Where the reading of higher levels of current is desired, a larger shunt with an "uneven" ratio is required. This "uneven" ratio requires you to modify the respective display reading mathematically in order to obtain the actual value of current flowing. For example when using a "200 amp/100 millivolt" shunt (a "2:1 ratio") you must always multiply the display reading by a factor of two. (I.e., when 52.2 amps flows the display will read only "26.1" - thus requiring you to multiply by two to get 52.2, etc.) Use of a "200 amp/100 millivolt" shunt allows display readings of up to 200 amps, in the same fashion a "300 amp/100 millivolt" shunt allows readings to 300 amps (by your multiplication of the display reading by 3) and so on.

4.10.3 To install the shunt, refer to Figure 4A - 4C. Shunts are installed "in line" with the selected DC (-) negative conductor to be monitored by cutting said conductor, and terminating each of the new wire ends with ring connector lugs (crimped and soldered to the wire) which are then bolted to the shunts' input/output terminals. The Shunts' Signal Leads can be #22 ga. or larger wire terminated on the Shunts' Signal Terminals with "crimped on" ring connectors. (Always ensure that the entire length of Signal Lead is twisted around itself to prevent measurement error that can occur from "stray" or "induced currents" imposed by adjacent AC power conductors, etc.)

The most common pair of current values to measure are "net battery current" and "charging source current". (Figure 4B illustrates both of these being measured.) The second most common is "load current" and "charging source current". (Figure 4C illustrates both of these being measured.)

"Net battery current" is the 'bottom line' of what is going into or out of your system's battery(s) it can be either a positive or negative value. "Positive" when the battery is receiving more than it's giving (i.e., 'charging') - "negative" when it is giving more than it's receiving (i.e., 'discharging'). [It is the mathematical difference between your total "charging source current" and your total "load current".] Note that when the display reading is "negative", the red "Negative Reading" LED lights up - this is equivalent to a 'negative sign' in front of the display's reading.

FIGURE 4A: PRECISION CURRENT SHUNT LAYOUT

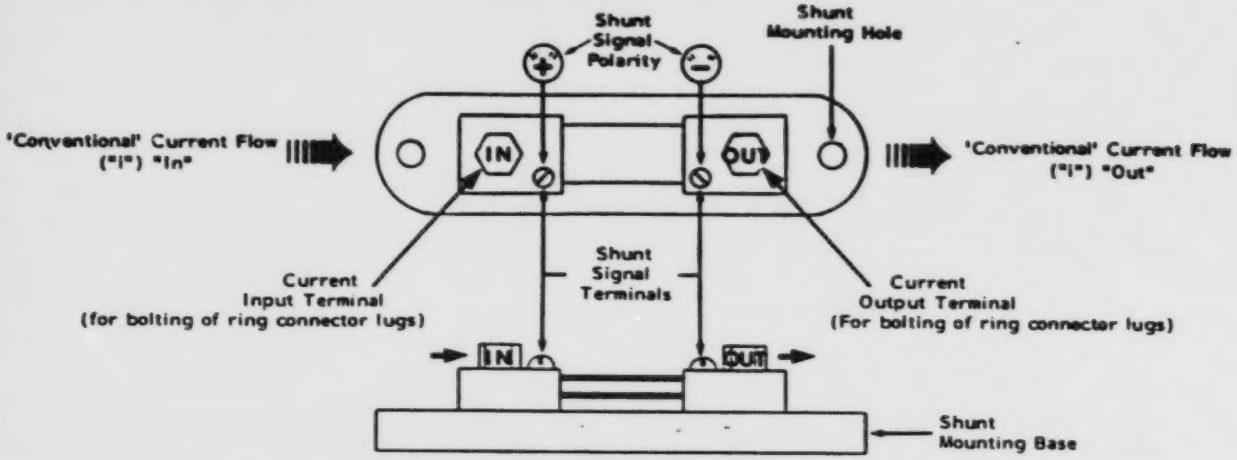


FIGURE 4B: Shunt Hookup Detail For The Measurement of "Net Battery" and "Charging Source" Currents

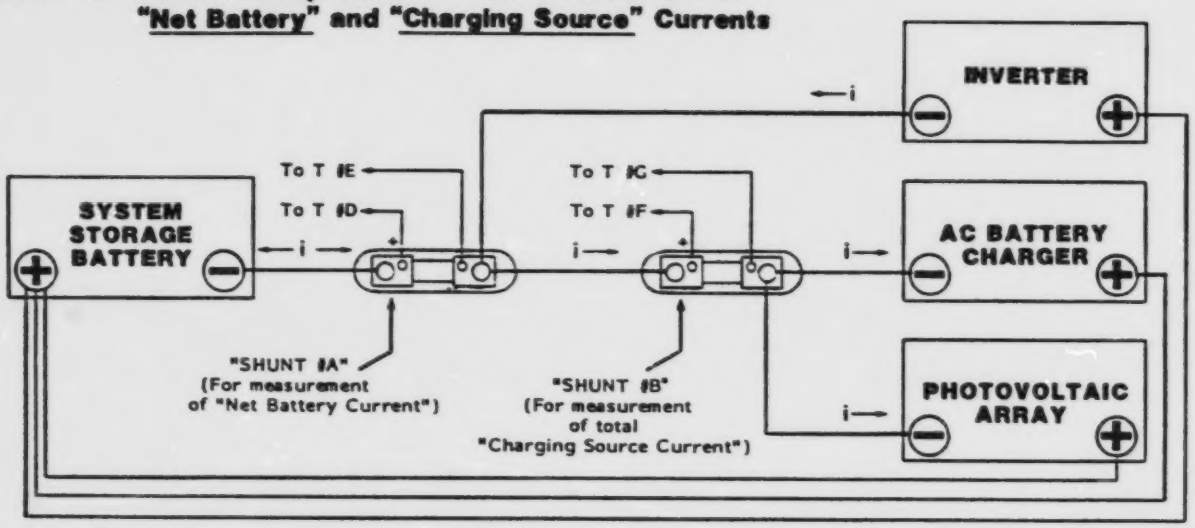
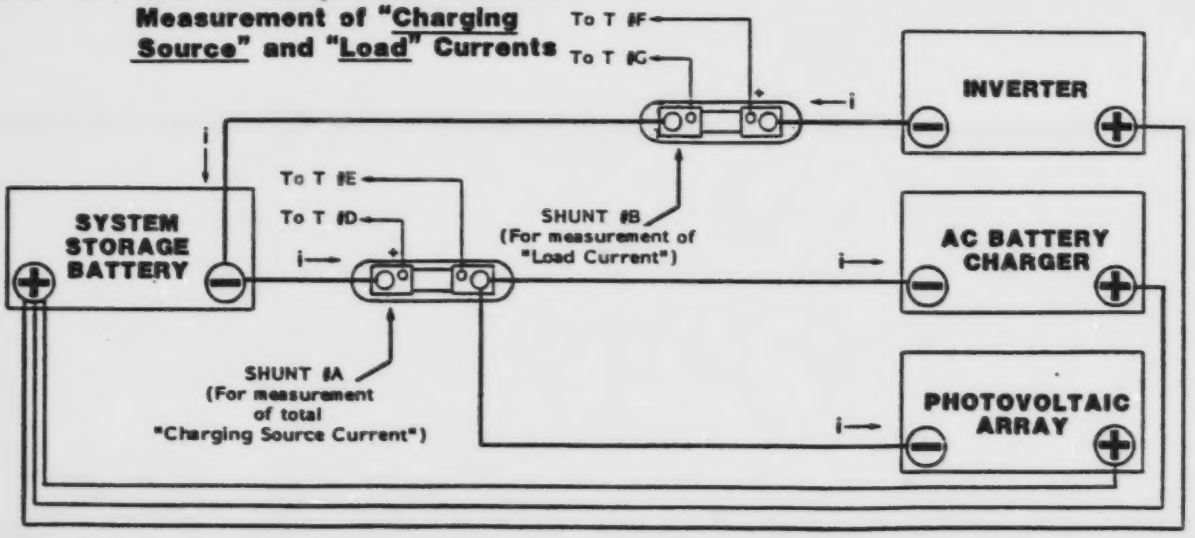


FIGURE 4C: Shunt Hookup Detail For The Measurement of "Charging Source" and "Load" Currents



"Charging source current" is the instantaneous amount of DC current actually generated by one or a combination of different battery charging sources such as AC battery chargers, photovoltaic modules, wind or hydro-generators, etc. These can be metered separately if desired, or combined into a "total" as shown in both Figures 4B and 4C.

"Load current" as the name implies is the instantaneous amount of DC current being drawn by whatever DC electrical loads (lights, appliances, tools, inverters, etc.) your system powers. These can be metered separately if desired, or combined into a more useful "total" as shown in Figure 4C.

Note that with combination inverter/battery charger products the same shunt that is installed to measure "charging current" (when the inverter is in its "charger mode") will also read "load current" (or discharging current) when the inverter is drawing current in order to operate in its "inverter mode" (supplying power to AC loads, etc.).

Shunt signals have a polarity to them which is determined by the direction of current flow across the shunt. If you can envision the current flowing like water in a pipe - then the terminal at which point the "water" is entering gives the "positive (+)" polarity signal - likewise the other end of the shunt where it then leaves gives the "negative (-)" polarity signal (assuming "conventional current" flow). (See Figure 4A.) It is important to assess the polarity of the respective shunt signal when making connections to TRANZAC T#D and #E; or #F and #G in order to ensure that the "Negative Reading" LED lights when it is supposed to! (I.e., to indicate a negative sign when the current flow is actually negative!) TRANZAC T#D and T#F are designated as the 'positive polarity' shunt terminals and T#E and T#G are their accompanying negative terminals respectively. Don't worry if you have difficulty understanding this concept - (we can't all be electrical engineers now can we?) if you make the signal connections in reverse no damage to the TRANZAC will occur. You'll simply get a "negative sign" when you're actually charging, etc. This is the System Analyzer's way of telling you to swap the connections! (REMEMBER - SHUNTS MAY ONLY BE INSTALLED IN THE NEGATIVE SIDE OF THE DC CIRCUIT! Refer to item #4.10 for details.)

5.0 GENERAL OPERATION

Once the installation procedure is complete, the TRANZAC may be put into operation as follows:

5.1 Set "CONTROL STATUS" Switch --- ALL MODELS

This switch programs the TRANZAC for the location from which it shall accept its 'mode of operation' instructions. Refer to the following Table #2 for assistance in determining the appropriate "CONTROL STATUS" switch position for your particular application:

TABLE 2: "CONTROL STATUS" SWITCH FUNCTIONS

"Control Status" Switch Position:	Operating Description...
"DISABLE"	Prevents internal transfer switch from activating, (unit will remain "latched" onto AC Source I). On UI and UI Digital units the internal electronic brain remains energized to constantly assess the battery condition, start generator as required, etc., but is prevented from controlling the internal transfer switch.
"LOCAL"	Allows only the Source Selector switch on the front door of the unit's enclosure to control the transfer switch's operation. On UI and UI Digital units the internal control circuit remains energized to constantly assess battery condition, start generator as required, etc., but is prevented from controlling the internal transfer switch.
"REMOTE"	Prevents the door mounted Source Selector switch from controlling the TRANZAC. On Standard and SH models, only the (optional) Remote Source Selector switch can determine when the internal transfer switch is to operate. On UI and UI Digital models the control is handled internally by the unit's electronic brain in response to battery condition, when the door mounted Source Selector switch is set to the "Auto Select" position. (I.e., no optional remote switches can be utilized.) Refer to 5.2 below for further details.

5.2 Set "SOURCE SELECTOR" Switch --- ALL MODELS

This switch tells the TRANZAC which AC Source it must use to power your AC loads. Refer to the following Table #3 for assistance in determining the appropriate "SOURCE SELECTOR" switch position for your particular application:

TABLE 3: "SOURCE SELECTOR" SWITCH FUNCTIONS

"Source Selector" Switch Position:	Operating Description...
"AUTO SELECT"	This position turns your TRANZAC into an "Automatic Transfer Switch". It allows the load to be powered by AC Source I for as long as AC Source II is unavailable. Once AC Source II becomes available (and after the preset warm-up period has elapsed) the transfer switch will automatically activate thereby transferring the load away from AC Source I, onto AC Source II. The moment AC Source II becomes unavailable, the transfer switch will place the load back onto AC Source I again and so on. On UI and UI Digital units only, the AUTO SELECT position can have additional capabilities. By first placing the "Control Status" switch to the "Remote" position, and then the "Source Selector" switch to the "Auto Select" position you can cause the TRANZAC to be controlled by an internal electronic brain which transfers the AC load in direct response to the condition of the battery. With the proper engine generator set, the internal brain can also automatically start, warm-up, and stop the gen set for emergency or back-up power. When your TRANZAC is not set up to "AUTO SELECT" (act as an Automatic Transfer Switch) by any of the means described above, it acts as a Manual Transfer Switch only. (See below)
"AC SOURCE I"	This position turns your TRANZAC into a "Manual Transfer Switch". It causes the TRANZAC to immediately select the AC source you have connected to T#7 and #8 for powering your AC load.
"AC SOURCE II"	This position turns your TRANZAC into a "Manual Transfer Switch". It causes the TRANZAC to immediately select the AC source you have connected to T#5 and #6 for powering you AC load.

5.3 TRANZAC FULLY OPERATIONAL === ALL MODELS

With the selector switches set to the desired positions, the TRANZAC is now fully operational. Table #4 provided below summarizes TRANZAC operation for all potential combinations of switch settings.

TABLE 4: MODE OF OPERATION VS. SWITCH SETTING

TRANZAC MODEL #	"CONTROL STATUS" SWITCH POSITION			"SOURCE SELECTOR" SWITCH POSITION			RESULTANT OPERATION
	"DISABLE"	"LOCAL"	"REMOTE"	"AUTO SELECT"	"AC SOURCE I"	"AC SOURCE II"	
All Models	X			X			Transfer Switch cannot operate, load is powered by AC Source I.
"	X				X		"
"	X					X	"
"		X		X			AC Source II powers load when available (after the preset "warm-up period" elapses); when not available AC Source I powers load.
"		X			X		AC Source I powers load at once.
"		X				X	AC Source II powers load at once.
Standard and "SH" Models			X	N/A			Only optional Remote Source Selector Switch Assembly #PTZ-1 can control Tranzac. (Operation is then identical to the three items immediately above.)
"			X		N/A		"
"			X			N/A	"
"UI" and "UI Digital"			X	X			Transfer Switch operates when system battery is at a (predetermined) low state of charge and AC Source II is available, (after the preset "warm-up period" elapses). AC Source I powers load at all other times.
"			X		X		Transfer Switch cannot operate. Only AC Source I can power load.
"			X			X	"

FIGURE 6A: TRANZAC EXTERNAL LAYOUT

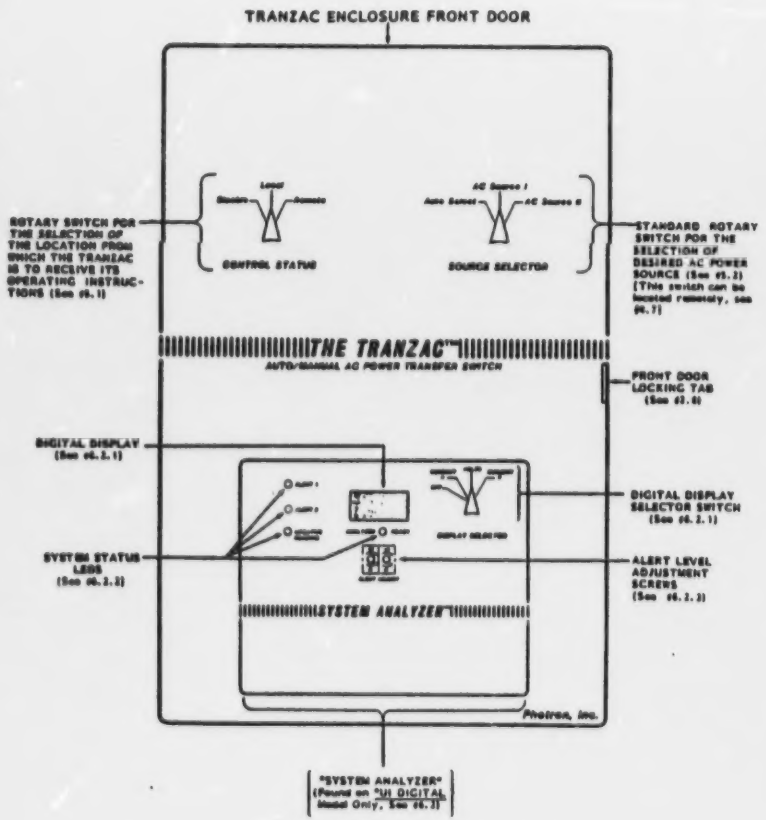
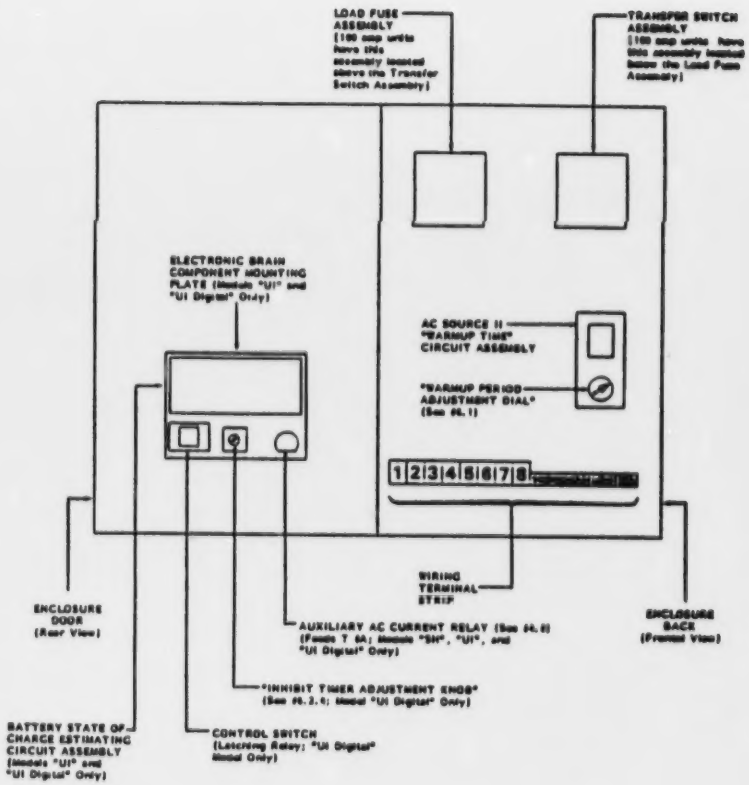

TRANZAC ENCLOSURE FRONT DOOR
ROTARY SWITCH FOR THE SELECTION OF THE LOCATION FROM WHICH THE TRANZAC IS TO RECEIVE ITS OPERATING INSTRUCTIONS (See 6.1)
CONTROL STATUS
SOURCE SELECTOR
STANDARD ROTARY SWITCH FOR THE SELECTION OF DESIRED AC POWER SOURCE (See 6.2) (This switch can be located remotely, see 6.7)
THE TRANZAC™
AUTO/MANUAL AC POWER TRANSFER SWITCH
FRONT DOOR LOCKING TAB (See 6.6)
DIGITAL DISPLAY (See 6.2.1)
DIGITAL DISPLAY SELECTOR SWITCH (See 6.2.1)
SYSTEM STATUS LEDS (See 6.2.2)
ALERT LEVEL ADJUSTMENT SCREWS (See 6.2.3)
SYSTEM ANALYZER™
Pharos, Inc.
"SYSTEM ANALYZER" (Found on "UI DIGITAL Model Only, See 6.3)

FIGURE 6B: TRANZAC INTERNAL LAYOUT


LOAD FUSE ASSEMBLY (100 amp units have this assembly mounted above the Transfer Switch Assembly)
TRANSFER SWITCH ASSEMBLY (100 amp units have this assembly mounted below the Load Fuse Assembly)
ELECTRONIC BRAIN COMPONENT MOUNTING PLATE (Models "UI" and "UI Digital" Only)
AC SOURCE II "WARMUP TIME" CIRCUIT ASSEMBLY
"WARMUP PERIOD ADJUSTMENT DIAL" (See 6.1)
1 2 3 4 5 6 7 8
WIRING TERMINAL STRIP
ENCLOSURE DOOR (Rear View)
AUXILIARY AC CURRENT RELAY (See 6.8) (Fuses T 6A; Models "SH", "UI", and "UI Digital" Only)
ENCLOSURE BACK (Front View)
"INHIBIT TIMER ADJUSTMENT KNOB" (See 6.2.4; Model "UI Digital" Only)
BATTERY STATE OF CHARGE ESTIMATING CIRCUIT ASSEMBLY (Models "UI" and "UI Digital" Only)
CONTROL SWITCH (Latching Relay; "UI Digital" Model Only)

6.0 SPECIAL OPERATION AND ADJUSTMENTS

!!!WARNING!!!

Remove all sources of power from your TRANZAC before attempting any internal adjustments. The opening of the unit's front door will otherwise expose persons to dangerous voltages that can cause severe bodily injury or even death. Adjustments should be made by properly qualified individuals only.

6.1 Warm-up Period Adjustment --- ALL MODELS

As mentioned earlier, when in the Auto Mode all TRANZACS apply a "warm-up period" (time delay) before allowing AC Source II to be connected to the load. This warm-up period can be adjusted over a range of from 3 seconds (min. setting) to 5 minutes (max. setting). By locating the "Warm-Up Period Adjustment Dial" (see Figure 6B) and turning it clockwise you can increase the length of the warm-up period. Likewise, by turning it counter-clockwise you can decrease the length of the warm-up period. The recommended (original factory) setting is ±"midway" in the range, which is equal to ±3 minutes.

6.2 System Analyzer Operation --- MODEL UI DIGITAL ONLY

The UI Digital units feature Photron's exclusive "System Analyzer" mounted on (through) the front door of the TRANZAC enclosure. In addition to performing its "electronic brain" functions (estimation of battery condition) the System Analyzer also provides a digital readout of DC battery voltage and two different DC Current values. LED indicators for negative display value, "Analyzer Ready", and two different "Alert" conditions.

6.2.1 To Utilize Digital Display Feature

Once properly wired per sections 3.0 and 4.0, operation of the digital display is simple. Locate the "Display Selector" knob and turn it to the value you wish to view. When finished be sure to turn the display off if you wish to avoid wasting the small amount of power the display draws to operate (less than 4 watts).

6.2.1.1 The "Volts" position reads out the voltage of the system's battery (at the point it is connected to the TRANZAC - e.g., at T#9 and #10).

6.2.1.2 The "Current A" position reads out the current flowing thru the shunt which is connected to T#D and #E. (See step #4.10 for details.) If no connection is made to T#D and #E the display will read "gibberish" (electrical nonsense) when on this position.

6.2.1.3 The "Current B" position reads out the current flowing thru the shunt which is connected to T#F and #G. (See step #4.10 for details.) If no connection is made to T#F and #G the display will read "gibberish" (electrical nonsense) when on this position.

6.2.2 Utilization of LED Indicators

6.2.2.1 "Negative Reading": When this LED lights it's just like the addition of a "minus sign" to the digital display value (much like that given by a standard hand held calculator, etc.).

6.2.2.2 "Analyzer Ready": This green LED lights when the System Analyzer is properly energized by the system's battery and hence ready to operate (or to assume its control duties where applicable). Failure of the green LED to light indicates either that TRANZAC terminals #9 and #10 have been hooked up incorrectly (or without sufficient input power) or that there is a fault condition somewhere within the TRANZAC itself. (See section 8.0 if necessary.)

6.2.2.3 "Alert #1": This LED lights when the system's battery voltage falls to the value preset by the "Alert Adjust #1" adjustment screw (or "pot") found just below the digital display. The LED indicates that the internal control switch (or "relay") has moved to a "closed" position (and that therefore TRANZAC T#B and #C are connected together - see item #4.9 above for details). The LED will go out as soon as the battery voltage rises slightly (about 1%) - THOUGH THE INTERNAL SWITCH WILL REMAIN CLOSED until the Alert #2 level has been reached.

This LED is usually employed, and is factory preset, to indicate that the battery is "low in charge" - though depending upon the "Alert Adjust #1" setting it can be used to indicate other things as desired.

6.2.2.4 "Alert #2": This LED lights when the system's battery voltage rises to the value preset by the "Alert Adjust #2" adjustment screw (or "pot") found just below the digital display. The LED indicates that the internal control switch (or "relay") is (back) in its "open" position. The LED will go out as soon as the battery voltage falls slightly (about 1%). This LED is usually employed, and is factory preset, to indicate that the battery is "high in charge" - though depending upon the "Alert Adjust #2" setting it can be used to indicate other things as desired.

6.2.3 Adjustment of "Alert" Levels

Your System Analyzer has been preadjusted at the factory to trigger "Alert #1" @ 1.83 volts per cell (this is equal to 11.0 volts for a 12 volt battery system, or 22.0 volts for a 24 volt battery system, etc.); and "Alert #2" @ 2.5 volts per cell (equal to 15.0 volts for a 12 volt battery system, or 30.0 volts for a 24 volt battery system, etc.). These trigger values can be changed by adjusting the "pots" mentioned above. The adjustment procedure is a bit tricky so please proceed very carefully as follows:

6.2.3.1 The "pots" are extremely delicate, and have a very wide range of electrical but not mechanical adjustability - NEVER TURN THEM CARELESSLY. Using a small "jewelers type" screwdriver or other light duty screwdriver GENTLY turn the pot in the desired direction as indicated by the arrows which surround them. ("LO" means you are lowering the particular Alert setting, "HI" means you are raising it.)

6.2.3.2 The new value you are setting is not readable from the units digital display in a direct manner. This is why the adjustment procedure is "tricky" (without an adjustable lab power supply - the proper adjustment tool - you have to be a little "creative" here). To read what has become your new setting after an adjustment is made you must essentially turn the digital display to the "Volts" position and "wait" for the particular Alert level (LED) you are setting to "trigger" (actuate). The display reading at the moment of LED actuation then tells you what your new setting value is. Alternately, if you watch the display and turn the pot in either direction until the respective LED lights up - you have just set the Alert level to the display value.

Now the trick is to make the display value read what you want to set the Alert level to! A simple way to do this without laboratory equipment is to 'turn on loads' to cause power to flow out of the system battery (which will cause the display reading to begin falling) or to turn on charging sources to get power to flow into the battery (which will cause the display reading to begin increasing). This procedure will take a little time and patience but is the surest means of altering the factory adjustment when a lab technician isn't handy!

CAUTION: Never force the adjustment screws or you will quickly destroy them (voiding the product warranty of course!). The screws are delicate and must be handled very gently. If they won't turn any further it means that you have reached their limit of adjustment. (Force them and they'll have the "last laugh"!)

6.2.4 Adjustment of Low Voltage (Gen Start) Inhibit Period

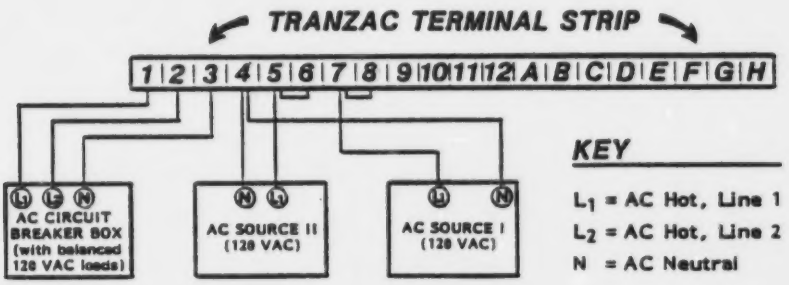
Your System Analyzer incorporates a special circuit (refer to step #4.9.3 for details) which prevents momentary dips in battery voltage from fooling it into causing false generator starts, etc. (i.e., false closure of the internal control switch). This circuit is adjustable for inhibit periods of from 6 seconds to 8 minutes. The recommended (original factory) setting is 8 minutes. To adjust this setting locate the "Inhibit Timer Adjustment Knob" (see Figure 6B) and turn it to point to the number denoting the amount of delay period you desire.

7.0 TRANZAC APPLICATIONS

Because of its sophisticated design, your TRANZAC is capable of being applied in many different ways in order to solve/serve a wide variety of power system problems/needs. The following explanatory figures are offered to facilitate proper selection and hook-up for a few of the most common TRANZAC applications. (Others are possible, contact Photron's Engineering Dept. for assistance with unique applications not discussed here.)

7.1 Installations with "120 VAC Only" Sources and Loads

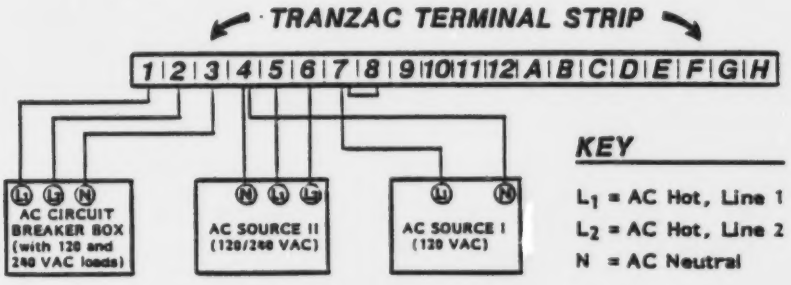
(Note: Only relevant terminal connections are shown here for clarity.)


TRANZAC TERMINAL STRIP
1 2 3 4 5 6 7 8 9 10 11 12 A B C D E F G H
AC CIRCUIT BREAKER BOX (with balanced 120 VAC loads)
AC SOURCE II (120 VAC)
AC SOURCE I (120 VAC)
KEY
L1 = AC Hot, Line 1
L2 = AC Hot, Line 2
N = AC Neutral

Note: Proper balancing of 120 VAC loads is essential to prevent unnecessary failure ("blowing") of Load Fuses.

7.2 Installations with a 120 VAC Source I and 120/240 VAC Source II

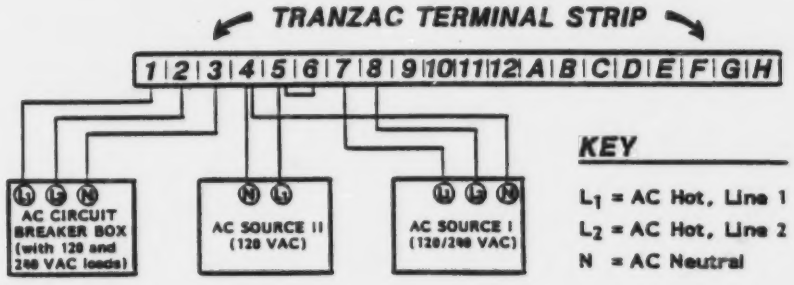
(Note: Only relevant terminal connections are shown here for clarity.)


TRANZAC TERMINAL STRIP
1 2 3 4 5 6 7 8 9 10 11 12 A B C D E F G H
AC CIRCUIT BREAKER BOX (with 120 and 240 VAC loads)
AC SOURCE II (120/240 VAC)
AC SOURCE I (120 VAC)
KEY
L1 = AC Hot, Line 1
L2 = AC Hot, Line 2
N = AC Neutral

Note: This type of hook-up will enable all of the system's 120 VAC loads to be powered by either AC Source, but allows 240 VAC loads to be energized only by AC Source II!

7.3 Installations with a 120/240 VAC Source I and 120 VAC Source II

(Note: Only relevant terminal connections are shown here for clarity.)

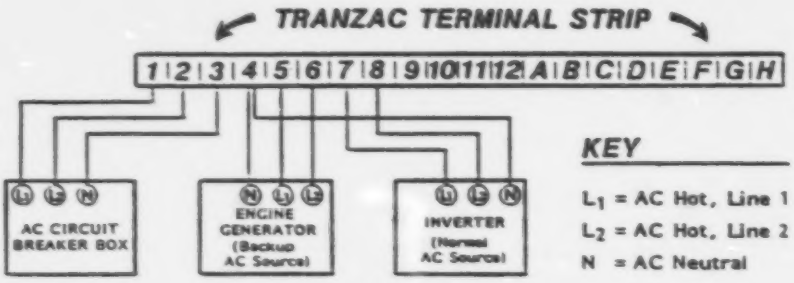

TRANZAC TERMINAL STRIP
1 2 3 4 5 6 7 8 9 10 11 12 A B C D E F G H
AC CIRCUIT BREAKER BOX (with 120 and 240 VAC loads)
AC SOURCE II (120 VAC)
AC SOURCE I (120/240 VAC)
KEY
L1 = AC Hot, Line 1
L2 = AC Hot, Line 2
N = AC Neutral

Note: This type of hook-up will enable all of the system's 120 VAC loads to be powered by either AC Source but allows 240 VAC loads to be energized only by AC Source I!

7.4 "Stand Alone" AC Power Systems

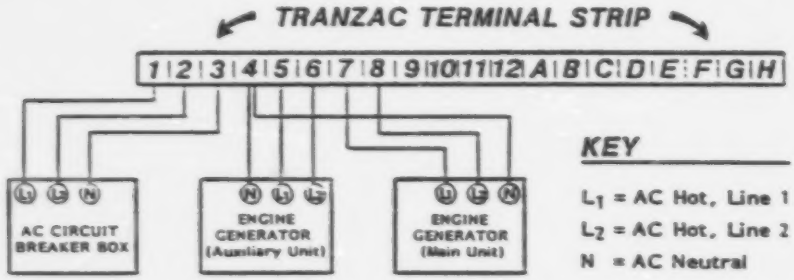
(Note: only relevant terminal connections are shown here for clarity.)

7.4.1 "INVERTER with ENGINE GENERATOR BACK-UP"


TRANZAC TERMINAL STRIP
1 2 3 4 5 6 7 8 9 10 11 12 A B C D E F G H
AC CIRCUIT BREAKER BOX
ENGINE GENERATOR (Backup AC Source)
INVERTER (Normal AC Source)
KEY
L1 = AC Hot, Line 1
L2 = AC Hot, Line 2
N = AC Neutral

Note: This type of system powers the AC Load from the inverter until a decision to go to the engine generator is made. (This may be during inverter servicing, back-up engine generator battery charging, or to run loads that can only be powered by the generator, etc.)

7.4.2 "DUAL ENGINE GENERATORS": (One as Main Unit the other as Auxiliary)

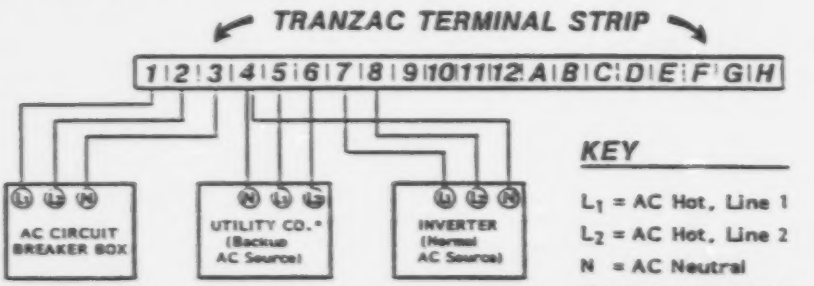

TRANZAC TERMINAL STRIP
1 2 3 4 5 6 7 8 9 10 11 12 A B C D E F G H
AC CIRCUIT BREAKER BOX
ENGINE GENERATOR (Auxiliary Unit)
ENGINE GENERATOR (Main Unit)
KEY
L1 = AC Hot, Line 1
L2 = AC Hot, Line 2
N = AC Neutral

Note: This type of system rotates the AC Load between two different engine generators such that one generator is always "at rest". These systems allow for the servicing of one of the generators without ever breaking the supply of power to the Load. The result is a more reliable, more continuous source of AC power from gen sets.

7.5 "Utility Connected" AC Power Systems

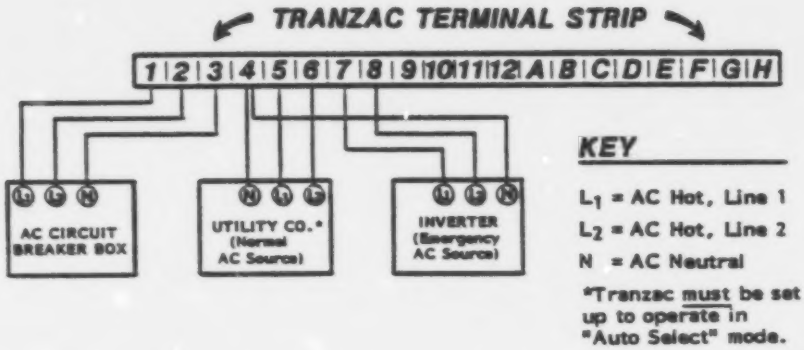
(Note: Only relevant terminal connections are shown here for clarity.)

7.5.1 "INVERTER with UTILITY COMPANY BACK-UP"


TRANZAC TERMINAL STRIP
1 2 3 4 5 6 7 8 9 10 11 12 A B C D E F G H
AC CIRCUIT BREAKER BOX
UTILITY CO.* (Backup AC Source)
INVERTER (Normal AC Source)
KEY
L1 = AC Hot, Line 1
L2 = AC Hot, Line 2
N = AC Neutral
*Tranzac must not be set up to operate in "Auto Select" mode.

Note: This type of system normally runs its AC Loads from the inverter until the system batteries are discharged to their maximum allowable limit. Loads are then switched onto the utility line, while the system batteries are recharged as the inverter "rests". When the batteries are fully recharged, the Load is once again switched onto the inverter and the cycle is repeated. These systems are sometimes referred to as "Uninterruptible Power Systems" (sic).

7.5.2 "UTILITY COMPANY with INVERTER BACK-UP"


TRANZAC TERMINAL STRIP
1 2 3 4 5 6 7 8 9 10 11 12 A B C D E F G H
L1 L2 N
AC CIRCUIT BREAKER BOX
N L1 L2
UTILITY CO.* (Normal AC Source)
N L1 L2
INVERTER (Emergency AC Source)
KEY
L1 = AC Hot, Line 1
L2 = AC Hot, Line 2
N = AC Neutral
*Tranzac must be set up to operate in "Auto Select" mode.

Note: This type of system normally runs its AC Loads from the Utility Company's power line. In the event of a Utility Company Power Failure ("blackout"), the AC Load is automatically switched onto the inverter until Utility Service is properly restored. These systems are accurately referred to as "Standby Power Systems" (for Utility AC Outage Protection).

8.0 MAINTENANCE/TROUBLE SHOOTING

Your new TRANZAC requires no routine maintenance once properly installed. As with any switch or relay actuated device (wall switches, circuit breakers, etc.) it is a good idea to "cycle" (i.e., cause it to transfer) the TRANZAC periodically (every six months or so) if it is to spend years sitting idle (without transferring) - especially if your installation is in a damp, humid, or salty environment. (The TRANZAC utilizes self cleaning contacts that "wipe" their surfaces each time they operate - this keeps them clean and ready to properly conduct electricity.)

8.1 Should your TRANZAC ever fail to perform as expected, observe the following troubleshooting procedure:

8.1.1 Be sure that you have the right TRANZAC for your job by reading the Model # on the unit's ID tag (see last paragraph of Section #1.0). Verify that the last two numbers in the TRANZAC Model # match your nominal system battery voltage (e.g., a "#PTZ-240/30-24UI" is a nominal 24 volt unit for nominal 24 volt systems, etc.).

8.1.2 Diligently check your wiring. Over 99% of all service problems are a result of improper hook-up. (That's why these instructions are so detailed!)

8.1.3 Verify that you have made the proper "Source Selector" and "Control Status" switch settings for your particular application. (See Section 5.0 for reference.)

8.1.4 Should the problem not be isolated from the above, the following steps may be taken by a properly qualified individual with the assistance of a handheld AC/DC Voltmeter.

!!!WARNING!!!

THE FOLLOWING STEPS REQUIRE MAINTENANCE PERSONNEL TO OPEN THE TRANZAC ENCLOSURE WHILE IT IS FULLY ENERGIZED. THIS EXPOSES PERSONNEL TO POTENTIALLY LETHAL VOLTAGES. GREAT CARE MUST BE TAKEN TO PREVENT CONTACT WITH ELECTRICALLY LIVE CIRCUIT ELEMENTS THAT COULD RESULT IN SEVERE BODILY INJURY OR EVEN DEATH. ONLY PROPERLY QUALIFIED INDIVIDUALS SHOULD ATTEMPT THIS WORK!

A) Turn "Control Status" switch to "Disable" position.

B) Ensure that both of your AC Sources are "on" and capable of producing their rated voltage.

C) Now check to see if the proper system voltages are in fact present in the TRANZAC at its terminal strip:

TABLE 6: TROUBLE SHOOTING PROCEDURE

PROCEDURE:	RESULT:	REMEDIAL ACTION:
-SET VOLTMETER TO A SCALE CAPABLE OF READING 200 VAC-		
1) Measure Voltage Across T#7 and T#4	-Reads less than 100 VAC or over 140 VAC	AC Source I improperly wired or malfunctioning. Repair as necessary.
	-Reads 100 - 140 VAC	AC Source I "OK"; proceed to step 2.
2) Measure Voltage Across T#5 and T#4	-Reads less than 100 VAC or over 140 VAC	AC Source II improperly wired or malfunctioning. Repair as necessary.
	-Reads 100 - 140 VAC	AC Source II "OK"; proceed to step 3.
3) Measure Voltage Across T#1 and T#4 (with as many AC Loads turned "on" as possible so that current is flowing thru the TRANZAC)	-Reads less than 100 VAC	Load Fuse(s) faulty or blown ("open"). Fully de-energize TRANZAC and replace fuse(s) with spares provided. Recheck when replacement is complete. [If fuses are in fact "OK" repeat steps 1 and 2 above with the Loads turned "on" this time.]
	-Reads 100 - 140 VAC	Load Fuse(s) "OK"; proceed to step 4.
-SET VOLTMETER TO A SCALE CAPABLE OF READING 200 VDC-		
4) Measure Voltage Across T#9 and T#10 with the black meter probe on T#9 and the red meter probe on T#10	-Reads less than 85% or more than 135% of your system's nominal DC battery voltage (as indicated by the units ID tag- (see #8.1.1 above) or reads REVERSE POLARITY (e.g. meter reads negative)	DC Battery Input improperly wired or malfunctioning. Repair as necessary. (Ensure proper polarity!)
	-Reads 85 to 135% of your system's nominal DC battery voltage (as indicated by the units ID tag- see #8.1.1 above) and polarity is "positive".	DC Battery Input "OK"; proceed to below - #8.1.5

8.1.5 If steps 1 - 4 did not isolate the problem as being external to the TRANZAC, then you may have a malfunctioning unit. Call your local dealer for service. Do not attempt to service the TRANZAC yourself. UNAUTHORIZED SERVICING OF THIS EQUIPMENT VOIDS FACTORY WARRANTY!!!

8.1.6 If satisfactory service is unobtainable for any reason, contact Photron, Inc. at the phone number or address listed on or next to the ID tag, or call (707) 459-3211 and request technical assistance from the Engineering Dept.

-SAVE THESE RECOMMENDATIONS FOR FUTURE REFERENCE-

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The "Ac source 1" setting is the selection for the inverter which is the primary output of the system.

"Ac source 2" is the switch selection for the generator output which is the auxilliary supply. These settings are used to over-ride the transfer switch inside the TRANZAC and will not normally be used. Refer to Page 9 of the TRANZAC Installation Recommendations.

If either of these settings are selected while the generator is already running the source will be transferred to that indicated ie. if Ac source 1 is selected from the auto select position while the generator is already running, the loads in the house will be then supplied by the inverter which will start up, the generator will still continue to run and supply power to the charger but not to the loads in the house.

Note that loss of power to the household circuits could occur if the AC source 2 setting is selected (ie. from the generator) and while in this position the batteries become fully charged and signals the generator to shut down, the generator will shut down but the TRANZAC will not transfer the loads to the inverter as the automatic function has been overridden by the selection of the AC source 2 setting.

3.3.3 Display Selector

The display selector controls the input to the digital display on the unit. There are 3 different options which can be displayed. These are the net battery current, the battery volts, and the array current.

"Current A"

In the current A position the display selector switch shows on the digital display the net battery current in amps. If there is no light illuminated on the left-hand side at the "negative reading" light, the figures shown are positive indicating a net flow of current into the battery to build up the storage. If the negative reading light is lit, it indicates a negative flow i.e. there is current being drawn from the battery and the storage is

being depleted.

The figure shown must be multiplied by 2 to indicate the true amount of current for the reading.

"Volts"

In this position the reading shown is the actual battery terminal voltage of the system in volts.

"Current B"

The current B reading is a direct reading of amps input from the array and the figure shown is the exact figure and does not need to be multiplied by 2.

Alert 1

When the alert 1 light is illuminated, it indicates that the battery voltage has dropped to the level previously selected at which the charging should commence by the generator. Note that there is a 20 minute delay on this light to avoid false starts because of spikes so that the generator will not start until 20 minutes after the alert 1 light comes on and remains on for the 20 continuous minutes.

If the alert 1 light remains on after the 20 minutes a malfunction could be indicated and the system should be watched very closely to determine if the generator is functioning properly.

Under normal conditions once the generator has commenced charging the system, the alert 1 light will go out.

Alert 2

The alert 2 light when illuminated indicates that the battery terminal voltage has reached the selected level to shut down the generator and the generator will immediately shut down once this light comes on. The light should extinguish very shortly after the generator has stopped.

Alert Adjust

The alert adjust potentiometers are to vary the settings for the alert 1 and the alert 2 lights. They will not normally be modified by the householder.

SECTION 3.4 KILOWATT POWER METERS

The top kilowatt power meter on the control board is reading the 120 volt AC output from the inverter and is read similar to an ordinary power meter in a regular house. It reads in kilowatt hours on the indicator dials.

The lower power meter is one that reads the 240 volt Ac output from the generator again in kilowatt hours on the indicator dials.

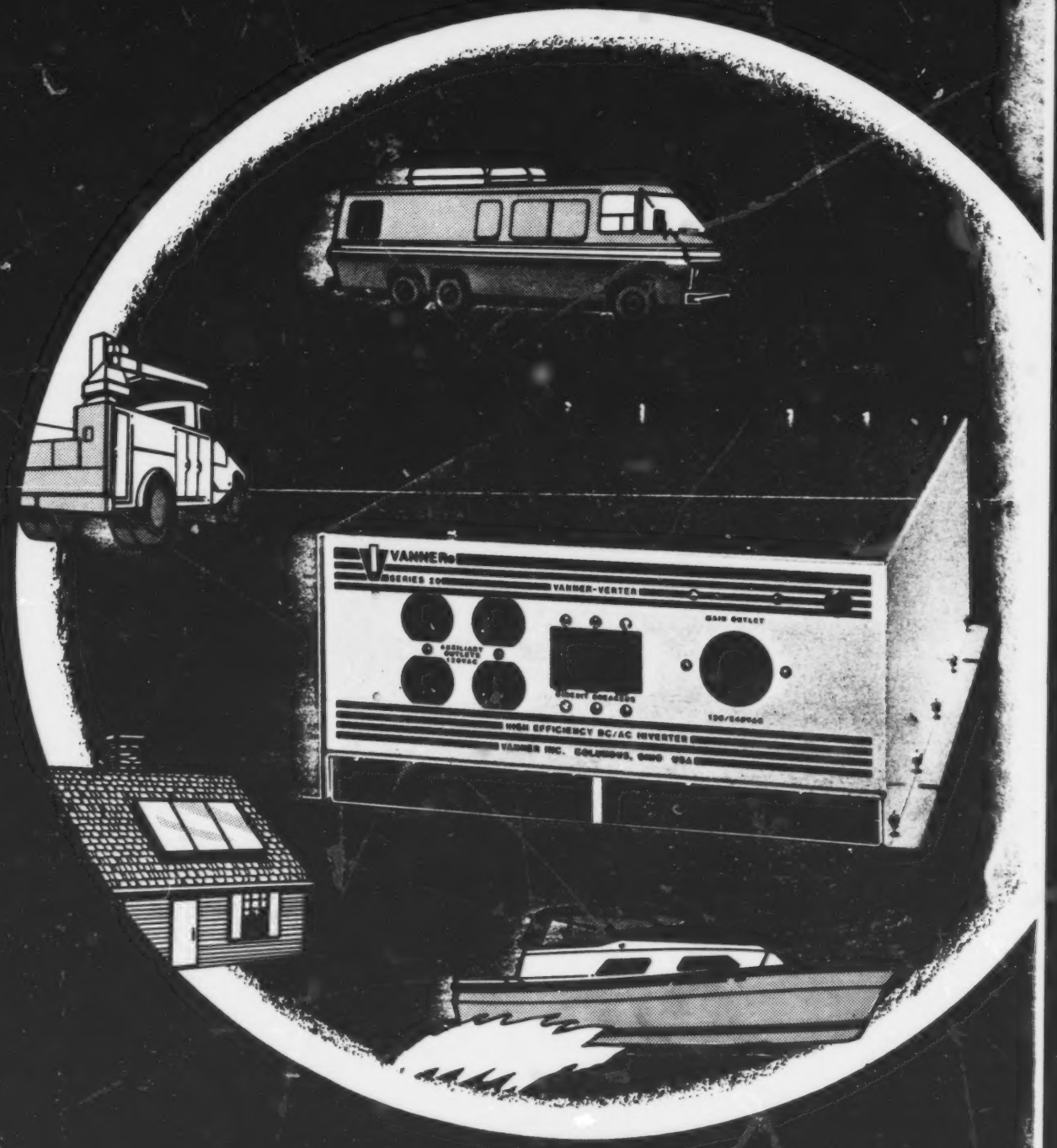
SECTION 3.5 INVERTER

The inverter's function is to convert the stored DC power in the batteries into alternating 110 volt ac current that can be used in the household.

This inverter unit is a Vanner 24-3000PF unit which will supply 3000 watt constant load and can handle surges up to 4800 watts. Its output is 60 Hz 120 volts ac. It is a very efficient unit and has a very low standby loss when no household loads are on. If there is no load required, ie. no appliances or lights are on in the residence, the inverter will remain off until a load is called for.

The operation of the inverter is completely automatic and should require no attention by the occupant. It is described in the descriptive sheet enclosed.

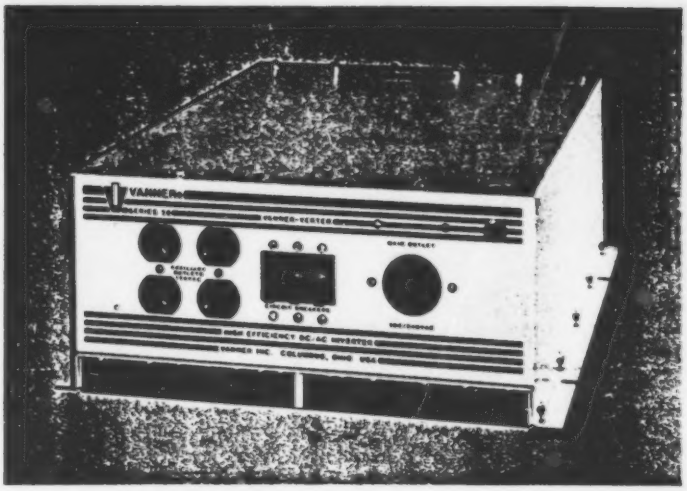
The orange light on the bottom of the inverter as mounted indicates that there is a load being supplied by the inverter. When there is no load being called for by the household the inverter is in the standby mode and the


VANNER
VANNER-VERTER
HIGH EFFICIENCY DC/AC INVERTER
VANNER INC. COLUMBUS, OHIO USA

VANNER-VERTERS...

the first universal load inverter

VANNER-VERTERS are designed to provide efficient ac power from a 12, 24, or 48 volt dc source to operate all types of electrical loads including:
Microwaves • Refrigerators
Air Conditioners • Ice Makers
TV's • VCR's • Stereos
Washers • Dryers • Pumps
Saws • Drills and Lights



IMPORTANT FEATURES

RMS VOLTAGE REGULATION

With Vanner's patented RMS voltage regulation, there is less than 1.5% variation from no load to full load. This means that your sensitive electronic equipment, tape decks and VCR's will operate properly, even when there are high and low deviations in battery voltage. This allows the use of alternators, power supplies, and photovoltaic systems.

CRYSTAL CONTROLLED FREQUENCY

Vanner regulates output frequency to better than 60 Hz ± 0.01 Hz. Frequency regulation is essential for operating VCR's, computers and sensitive electronic equipment.

LOW STANDBY LOSS

When idling in the load demand mode, the Vanner-Verter draws less than 0.05 amps.

RELIABILITY

Our inverters are acclaimed for their long life and service. Added cost features such as cooling fans are built in because heat is the major cause of all component failure in electronic equipment. Cooling under heavy loads and high ambiant temperatures extends life.

Most inverters are designed with transistors or FETs operating at full capacity. Vanner's patented "Darlington" design allows transistors to operate at only ¼ of their capacity, extending life and providing high surge capability.

HIGH EFFICIENCY

High efficiency and power factor capability are paramount in extending battery life. Vanner "PF" model inverters provide the most usable power for the least amount of battery input.

CONVENIENT INSTALLATION

Simply connect to the batteries with matching battery quick connectors which are supplied.

LOAD DEMAND OPTION

Vanner-Verter PF models are supplied as **standard** with the load demand option. If this option is enabled, the inverter will remain off until a load is applied. When the load is removed, the inverter will switch back to standby. This option is user-selectable.

LOW BATTERY CUTOFF OPTION

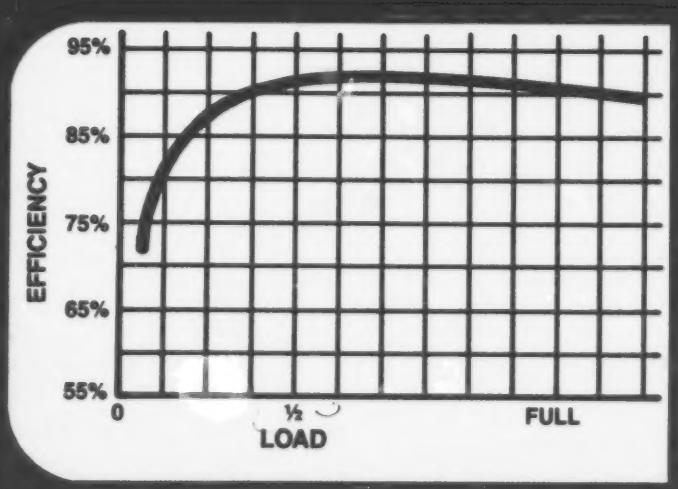
Vanner-Verter PF models are supplied as **standard** with the low battery cutoff option. During normal operation, if battery input voltage drops below a preset level, the inverter will automatically turn off thereby preventing over-discharge battery damage. This option is also user-selectable.

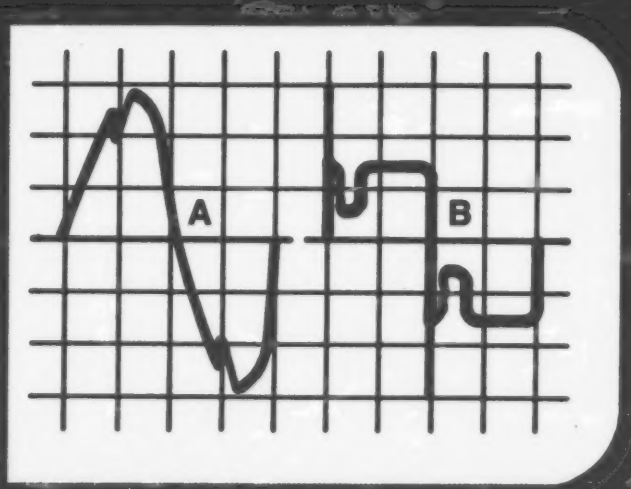
REMOTE CONTROL

A lighted remote control switch is provided as standard equipment.

THERMAL SWITCH OPTION

A thermal cutoff fan switch is available to reduce current draw under light load operating conditions.


95%
85%
75%
65%
55%
EFFICIENCY
0
½
LOAD
FULL


A
B

APPLICATION INFORMATION

Vanner original equipment manufacturers and distributors are knowledgeable and well equipped to guide you in the designing of alternate energy systems. They first determine the amount of current needed, depending on the type of appliances you want in your system. They will then determine the power level of the inverter, the number and size of batteries, and the recharging equipment necessary to supply adequate current to the batteries. These include photovoltaic cells, wind generators, ac line power, alternators, ac generators, or a combination of these sources of energy.

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745 HARRISON DRIVE
COLUMBUS, OHIO 43204
614 272-6263

Catalog No. PF-585

Litho in USA 1094 5 85

light will go out. This does not indicate a malfunction.

The 2 switches on the inverter are circuit breakers which protect the inverter from overload situations. Both the circuit breakers should be left in the "on" position.

SECTION 3.6 CONTROL ENCLOSURE

3.6.1 GEN WIZARD CONTROL UNIT

3.6.1.1 Control Mode Switch

"Autostart" Position

Under normal conditions this switch will be left in the "autostart" position. This allows the gen set to start automatically as required to recharge the batteries when low.

"Manual Start" Position

If at any time it is desired to start the generator from the control panel without going outside and when the system is not normally calling for the generator to start, selecting the "manual start" position, will send to the generator a signal to start. The generator should start immediately on this setting being selected.

IT WILL SHUT DOWN AUTOMATICALLY when the switch is returned to the "autostart" position.

"Disable" Position

If at any time work is required either on the gen wizard controller or on the generator itself the disable setting should be selected so that the generator will not start automatically from the internal controls.

photron inc.

Energy Systems

Installation Recommendations

-IMPORTANT-

PLEASE READ THESE RECOMMENDATIONS CAREFULLY BEFORE ATTEMPTING TO INSTALL OR OTHERWISE OPERATE THIS PHOTRON PRODUCT.

!!!WARNING!!!

ELECTRICITY (EVEN LOW VOLTAGE ELECTRICITY) CAN BE VERY DANGEROUS. PHOTRON, INC. RECOMMENDS THAT ALL ELECTRICAL INSTALLATIONS - INCLUDING THE INSTALLATION OF THIS PRODUCT - BE PERFORMED ONLY BY LICENSED OR PROPERLY QUALIFIED INDIVIDUALS AND IN STRICT ACCORDANCE WITH APPLICABLE BUILDING AND ELECTRICAL CODES.

1.0 PRODUCT DESCRIPTION

The GEN-WIZARD™ is an advanced state-of-the-art engine generator start controller. Though it serves several discrete functions, it's basic purpose is to convert the '3-wire' electric starting systems of common engine generators (or "gen sets") into '2-wire' systems so that they may be controlled simply and automatically by remote switch operation or electronic control such as that provided by Photron's "Brain", "Sentry", or "Tranzac UI" products, etc. (see respective product literature for more information or contact Photron's Sales Dept. for assistance).

In addition to its basic '3 wire to 2 wire start adapter' function the GEN-WIZARD also provides the following:

- manual gen set on/off control
- gen set start system testing and disabling
- gen set over-crank protection and control (crank time is fully user-adjustable)
- means of selection for the individual control of 2 physically different (but identically starting) gen sets
- visual and auditory alarms for gen set start failures as well as a signal output for remote alarms or sequential aux. gen set starting
- a visual indicator for 'gen set running'
- remote control reactivation of gen set start sequence after an overcrank condition
- convenient terminal connection point for remote gen set control and monitoring

NOTE: IN ORDER TO ENSURE PROPER GEN-WIZARD OPERATION, IT IS CRITICAL THAT THE UNIT BE DESIGNED WITH YOUR GEN SET'S START SYSTEM IN MIND, AND INSTALLED EXACTLY PER INSTRUCTIONS. NOT ALL GEN SETS START ALIKE, THEREFORE NEVER EMPLOY A GEN-WIZARD WHOSE PART NUMBER (FOUND ON THE UNIT'S ID LABEL) DOES NOT CONTAIN THE BRAND NAME OF EACH OF THE GEN SETS IT IS TO CONTROL. FAILURE TO OBSERVE THIS WARNING MAY DAMAGE THE GEN-WIZARD AND VOID THE PRODUCT'S WARRANTY. IT IS ALSO IMPORTANT TO ENSURE THAT ANY GEN SET TO BE REMOTE CONTROLLED HAVE A PROPERLY FUNCTIONING AUTOMATIC-CHOKE SYSTEM FOR RELIABLE (COLD) STARTING.

2.0 LOCATION

Mount the GEN-WIZARD in an indoor area that is protected from wind, rain, excessive dust, moisture and heat as you would a standard household radio or TV. Do not mount the unit directly onto a generator.

The GEN WIZARD may be mounted in any position desired; the 4 holes in the chassis flange are provided for this purpose.

Ideally the GEN-WIZARD should be located near the generator(s) it is to control - but never confined within a sealed battery enclosure where hydrogen gas from normal battery charging might accumulate.

The GEN-WIZARD terminals will accept up to #12 gauge wire or terminal lugs. If larger gauge wire is used, a down converter to #12 is required. (This can be simply accomplished thru the use of a common "wire or twist nut", etc.) Be sure to anchor all wires that you connect to the GEN-WIZARD terminal strip within one foot of the unit so that no stress is placed upon the terminal strip itself.

Where the GEN-WIZARD is to be mounted out of the path of normal daily travel, use of Photron's optional POWER SYSTEM MONITOR is suggested. (This connects simply to the GEN-WIZARD terminal strip and allows monitoring and control of various GEN-WIZARD and gen set functions at any remote locale the user may desire.)

3.0 WIRING

Note: When making wire connections to the GEN-WIZARD be sure that the wires you are handling are fully de-energized and that the "CONTROL MODE" switch is set to the "DISABLE" position. Failure to do so may cause severe bodily harm or permanent damage to the GEN-WIZARD, voiding its warranty (not to mention your fingers!).

All connections to the GEN-WIZARD terminal strip should be made with #22 gauge (or larger) stranded wire for circuit runs of up to 50 ft. When circuit runs are to exceed 50 ft., care must be taken to install at least the following minimum wire sizes in order to prevent undue voltage drops and hence improper unit operation:

FOR TERMINALS #	LENGTH OF CIRCUIT RUN		
	50 - 100 FT.	100 - 500 FT.	500 - 1000 FT.
1, 2, 3, 5, 10, 11, 12, 13	#18 GA.	#12 GA.	# 8 GA.
7, 8	#22 GA.	#18 GA.	#14 GA.
4, 6, 9, 14	#22 GA.	#22 GA.	#22 GA.

Note: When using #22/10 remote signaling cable provided by Photron for normal GEN-WIZARD hookup, spare #22 conductors may be twisted together to form larger singular conductors. (Eg. (3) #22's = (1) #18, (7) #22's = (1) #14, (10) #22's = (1) #12, etc.)

Always provide proper overcurrent protection (1 amp minimum, 10 amp maximum) for each wiring run where it connects to any potential source of power (gen set AC output, gen set starting battery, etc.).

Figure I and its attendant text will aid the user in understanding the various GEN-WIZARD control functions and how to wire the unit in order to accomplish them.

4.0 HOOKUP DETAILS (refer to "IMPORTANT NOTICE" under Figure I)

Connections to the GEN-WIZARD terminal strip may be made in any order desired, however always place "CONTROL MODE" switch to "DISABLE" position before the start of any wiring to the unit.

The "Main Gen Set" input wiring (#'s 1 - 4) is mandatory, whereas the "Aux. Gen Set" input wiring is optional and hence used only when two gen sets with identical starting systems are to be controlled alternately. If trouble is experienced in locating the proper gen set wires to connect to, refer to gen set owner's manual, Photron's Amendment Sheet (if attached), Photron's supervisory wiring schematic for the power system (if supplied), or contact Photron's Engineering Dept. for assistance. (Never "guess" at the proper connection points.)

Never jumper any terminal positions (except for #7 and #8) together for any reason, severe damage to GEN-WIZARD, gen set(s), or external wiring may occur.

The input wiring to terminal #'s 1, 4, 5, 11, and 14 must be fused at their respective origins (fuse size should be 1 amp minimum, but must not exceed 10 amps maximum).

Terminals #7 and #8 are the remote starting contact positions. When these two terminals are connected together the selected gen set will start, when broken apart it will stop. Connect these terminals to any switch or relay contact ("dry" or "voltage free" only) desired to provide for remote (auto or manual) gen set start/stop control. Note that in the event of a "gen start failure" condition, momentarily opening and then reclosing the connection between these two terminals will "reset" the GEN-WIZARD and hence cause the selected gen set to begin another gen start sequence.

The polarity of terminal #9's output signal is a negative 12VDC on "Standard" (ONAN style) GEN-WIZARD models. For "Custom" units, refer to the Amendment Sheet (attached) for actual polarity before making connections as polarity will vary depending on individual gen set's start system type. This terminal may be connected to a remote visual or auditory alarm which consumes 1/20 of an amp @ 12VDC or less. The signal output from this terminal is given any time the "GEN START FAILURE" LED lights up (ie: when the gen set fails to start as commanded).

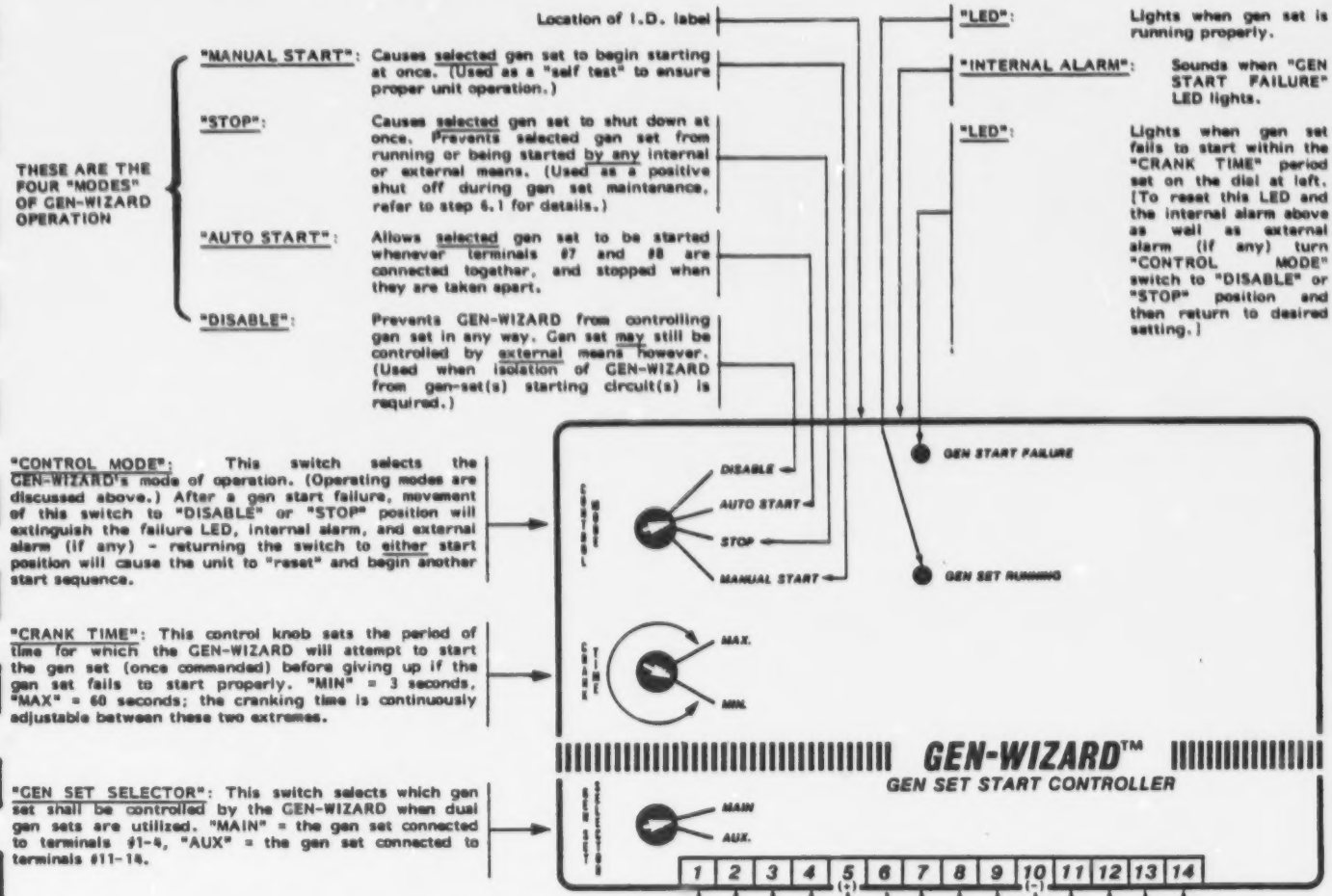
FIGURE 1: GEN WIZARD FEATURES AND CONCEPTUAL WIRING

IMPORTANT NOTICE

The GEN-WIZARD is custom built to control specific engine generator brands. The gen set brand that your unit was built for will appear on the I.D. label as the tail end of the unit's model number. Never employ the GEN-WIZARD for use with anything but the listed gen set brand (and model # if listed on the label under "OPTIONS"). When dual gen sets are to be controlled, their respective starting systems must be identical in design. Some custom units may require special modification resulting in an operating variation(s) from these instructions - if this applies to your unit refer to the Amendment Sheet attached for special instructions.

THIS GEN-WIZARD IS: (To be checked by Photron before shipment to user)

- ☐ A STANDARD UNIT (no Amendment Sheet is attached)
- ☐ A CUSTOM UNIT (refer to attached Amendment Sheet for details)


Location of I.D. label
"LED": Lights when gen set is running properly.
"INTERNAL ALARM": Sounds when "GEN START FAILURE" LED lights.
"LED": Lights when gen set fails to start within the "CRANK TIME" period set on the dial at left. [To reset this LED and the internal alarm above as well as external alarm (if any) turn "CONTROL MODE" switch to "DISABLE" or "STOP" position and then return to desired setting.]
THESE ARE THE FOUR "MODES" OF GEN-WIZARD OPERATION
"MANUAL START": Causes selected gen set to begin starting at once. (Used as a "self test" to ensure proper unit operation.)
"STOP": Causes selected gen set to shut down at once. Prevents selected gen set from running or being started by any internal or external means. (Used as a positive shut off during gen set maintenance, refer to step 6.1 for details.)
"AUTO START": Allows selected gen set to be started whenever terminals #7 and #8 are connected together, and stopped when they are taken apart.
"DISABLE": Prevents GEN-WIZARD from controlling gen set in any way. Gen set may still be controlled by external means however. (Used when isolation of GEN-WIZARD from gen-set(s) starting circuit(s) is required.)
"CONTROL MODE": This switch selects the GEN-WIZARD's mode of operation. (Operating modes are discussed above.) After a gen start failure, movement of this switch to "DISABLE" or "STOP" position will extinguish the failure LED, internal alarm, and external alarm (if any) - returning the switch to either start position will cause the unit to "reset" and begin another start sequence.
"CRANK TIME": This control knob sets the period of time for which the GEN-WIZARD will attempt to start the gen set (once commanded) before giving up if the gen set fails to start properly. "MIN" = 3 seconds, "MAX" = 60 seconds; the cranking time is continuously adjustable between these two extremes.
"GEN SET SELECTOR": This switch selects which gen set shall be controlled by the GEN-WIZARD when dual gen sets are utilized. "MAIN" = the gen set connected to terminals #1-4, "AUX" = the gen set connected to terminals #11-14.
DISABLE
AUTO START
STOP
MANUAL START
GEN START FAILURE
GEN SET RUNNING
MAX.
MIN.
MAIN
AUX.
GEN-WIZARD™
GEN SET START CONTROLLER
1 2 3 4 5 (+) 6 7 8 9 10 (-) 11 12 13 14
MAIN GEN SET INPUTS
#1 Main Gen Start Switch's Center Position (fuse at gen set, etc.)
#2 Main Gen Start Switch's "STOP" Position
#3 Main Gen Start Switch's "START" Position
#4 Main Gen Set AC HOT (fuse at gen set, etc.)
#5 Main gen set 12VDC starting battery positive (+) input (fuse at gen set, etc.)
#6 AC neutral input from Main (and Aux. if used) gen set(s)
#7 Remote start contact output
#8 Remote start contact output
#9 Remote "GEN SET START FAILURE" signal output
#10 Main gen set 12VDC starting battery negative (-) input
AUX GEN SET INPUTS (OPTIONAL)
#11 Aux. Gen Start Switch's Center Position (fuse at gen set, etc.)
#12 Aux. Gen Start Switch's "STOP" Position
#13 Aux. Gen Start Switch's "START" Position
#14 Aux. gen set AC HOT (fuse at gen set, etc.)

5.0 OPERATION

Once the GEN-WIZARD installation procedure is complete, the unit may be put into operation as follows:

5.1 Set "GEN SET SELECTOR" switch to desired gen set (either the "Main" or "Aux." unit). The GEN-WIZARD will only provide control to the "selected" gen set. (The other or "non-selected" gen set is not controlled or otherwise further effected in any way by the GEN-WIZARD, and hence can be operated by external means, etc.)

5.2 Set "CRANK TIME" knob to desired cranking period. ("MIN". = 3 seconds. "MAX." = 60 seconds: the actual time you set is continuously variable between these two extremes. I.e. halfway between "MIN." and "MAX." settings equals ± 30 seconds, etc.)

5.3 Set "CONTROL MODE" switch to desired operating mode. (E.g. "AUTO START" for remote automatic or manual gen set start/stop control, or "MANUAL START" if you wish to control the gen set from the "GEN-WIZARD" directly.) The GEN-WIZARD is now fully operational. Any time that terminals #7 and #8 are connected together, (with the unit set to "AUTO START") the selected gen set will start: when said contact is broken, the selected gen set will stop. Remember, the GEN-WIZARD will control (or "change the state of") only that gen set which has been selected by the "GEN SET SELECTOR" switch (refer to item #5.1 above for further details).

5.4 A Self-Test of the GEN-WIZARD'S protection circuitry may now be performed if desired:

- Set the unit to "STOP" mode.
- Go to selected gen set and remove all of its spark plug caps from their respective spark plugs.
- Return to the GEN-WIZARD and set the unit to "MANUAL START" mode. The gen set will now continue to crank (unsuccessfully) for the time period set by the "CRANK TIME" knob.
- At the end of this period the "GEN START FAILURE" LED will light, the internal alarm beeper will sound, and the external alarm output signal from terminal #9 will be given.
- Turning the knob to "STOP" mode, and then back to "MANUAL START", will cause the unit to silence, reset and then go thru yet another attempt at starting, etc.

5.4.1 To test for proper Manual operation:

- Set unit to "STOP" mode.
- Reconnect all of the spark plug caps.
- Return to the GEN-WIZARD and set the unit to "MANUAL START". The selected gen set should start per usual, and therefore activate the "GEN SET RUNNING" LED.
- Setting the unit to "STOP" should immediately shut the selected gen set off.

5.4.2 To test for proper Automatic operation:

- Set the unit to "AUTO START".
- Attach a wire from terminal #7 to #8. The selected gen set should start per usual, and the "GEN SET RUNNING" LED should light.
- Remove the wire from terminal #8. The selected gen set should stop at once.

(Note that a self test of the unit's protection circuitry as it operates while in the "AUTO START" mode may be made if desired by repeating the above with the selected gen set's spark plug caps removed, etc. per step #5.4. Resetting of the unit after the failure alarms are given can be then accomplished by the same means as discussed in step #5.4, or by briefly disconnecting and then firmly reconnecting the jumper wire to terminal #8, etc.)

6.0 SPECIAL OPERATING NOTES

6.1 Always set the unit to "STOP" before attempting any maintenance on the selected gen set or the GEN-WIZARD itself. [IMPORTANT NOTICE!!! - Though the gen set cannot be started or run in the "STOP" mode, external switches on the gen set itself or those wired independently of the Gen-Wizard, (or in parallel to the Gen-Wizard), may still cause the gen set to "crank" or "turnover" (unsuccessfully) if operated. Though the gen set will not start, the cranking action may be very dangerous to personnel if generator servicing is underway, etc. Therefore, always exercise extreme caution to ensure that such external control switches cannot be operated during maintenance, etc. Photron recommends that such external control means be avoided, disabled, or removed when the Gen-Wizard is utilized to prevent safety hazards to personnel. External control of the gen set should be made by using the Gen-Wizard's Remote Start Contacts (terminals #7 and #8) only in order to prevent complicated or confusing operating or maintenance procedures that may lead to trouble.]

6.2 Should the GEN-WIZARD ever fail to perform as expected, observe the following trouble-shooting procedure: (Always ensure that you have the proper Gen-Wizard model installed correctly, see "IMPORTANT NOTICE" under Figure I for details.)

6.2.1 First verify that the problem does not lie with the selected gen set itself by setting the GEN-WIZARD to "DISABLE" and then starting the gen set manually at the gen set. If the gen set cannot be started, repair accordingly. If it starts at once, proceed to step #6.2.2.

6.2.2 Check all input fuses to ensure that they are intact. If any are blown, locate the original cause of failure before fuse replacement.

6.2.3 Check for proper electrical polarity, voltage level, or continuity on all connections to the GEN-WIZARD terminal strip and remote control elements, etc. Correct if necessary.

6.2.4 If no obvious cause for the problem is discovered, call your local dealer for service. DO NOT OPEN THE GEN-WIZARD CHASSIS UNDER ANY CIRCUMSTANCES - THERE ARE NO USER SERVICEABLE PARTS INSIDE. (Failure to observe this warning will automatically void the product's warranty.)

6.2.5 If satisfactory service is unobtainable for any reason, contact Photron, Inc. at the phone number or address listed on the back of the chassis, or call (707) 459-3211 and request technical assistance from the Engineering Dept.

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"Stop" Position

This is like an emergency stop setting to stop the generator from the control panel when the generator set is running. This switch overrides other controls and should stop the generator under all conditions.

3.6.1.2 Crank Time

This setting determines how long the generator will crank in an attempt to start. It is adjustable from approximately 20 seconds to 3 minutes by rotating this dial.

3.6.1.3 Gen Set Selector Switch

This switch is used only when there is more than 1 generator set to supply the system. The switch will select either the main or the auxilliary generator as indicated. In this installation however there is only 1 generator and this switch must be left on the main setting at all times.

3.6.1.4 Gen Start Failure Light

This is the top light that lights when the genset fails to start within the "crank time" set on the dial of the gen wizard controller.

3.6.1.5 Gen Start Running Light

The gen start running light is lit when the generator has started and has come up to satisfactory voltage for normal operation.

3.6.2 BATTERY VOLTAGE REGULATOR

The "charging when lit" light is intended primarily to indicate when the array is supplying power and charging the system. This light however can be deceiving and does not necessarily mean that the array is actually supplying power to the system as the light works on a timer system as follows.

AN EXPLANATION OF THE REVERSE LEAKAGE PROTECTION TIMER IN THE BVR 30 CHARGER

Inside the Charger is some electronic circuitry that forces the charging relay open at night. This is done for 2 reasons:

1) to prevent power loss through reverse leakage to the solar panels, and

2) to stop the charging relay from consuming power by remaining energized.

The array "charging when lit" light is on when the charging relay is closed and off when the relay is open.

Here's how the timer works:

When the sun first rises in the morning, the timer senses this because the panel voltage is rising. This resets the timer; it is now in the "10 HOUR" mode. This means that ten hours after the sun rises, the timer will force the charging relay open to see if the panels are still producing power (when the charge relay is closed, the panels are connected directly to the batteries, and so it is not possible to tell when the panels are not producing any power).

If the relay is forced open and the panel voltage is above a minimum, and if the battery voltage falls to the charge reconnect voltage, then the relay will reclose. If the panels are not producing power, or if the battery voltage remains high, the relay will not reclose.

Also, when the timer makes the first check (ten hours after sunrise), the timer goes into the "2 HOUR" mode.

THE BVR-30

The BVR-30 is a medium cost, one and two step battery voltage regulator designed for the efficient control of larger 12,24,36,48 and 120 volt charging systems which utilize photovoltaics, hydrogenerators, and wind generators, etc. as power sources. It utilizes a series charging relay in order to allow it to handle greater amounts of power than the BVR-10, (consult specifications table for unit current ratings) and has a wider range of custom options available as well. The BVR-30 is housed in an anodized aluminum chassis for mounting indoors, or outdoors in weatherproof enclosures. The front mounted terminal block incorporates captive screw clamps which will accept up to 10 gauge wire or a variety of terminal connectors. All units include a full two year warranty.

Special Features Include:

- Metered and non-metered models
- Wide range of custom options
- High Efficiency (no voltage drop)
- Two step charging sequence (12 and 24 volt units only)
- Can handle up to 30 amps per unit
- LED charge indicator light
- Reverse leakage protection
- Lightning protection and noise suppression
- Reverse polarity protection
- Terminal position for load wiring
- Quiet operation

Available Custom Order Options:

- Temperature Compensation
- Different control setpoints
- Adjustability in control setpoints
- Power diversion
- Low voltage warning beeper (adj. or non-adj.)
- Weather and oil tight enclosures
- Low power relays
- Expanded operating temperature range (-20°C to 50°C)

OPERATING DESCRIPTION

(The following example is for a 12 volt unit) The BVR-30 will allow maximum charging current to flow into the battery via a series relay until battery terminal voltage reaches 14.8 volts.

During this charging stage the red "Charging When Lit" LED will glow indicating active full charging status. When the battery reaches 14.8 volts, however, the LED will turn off and the BVR-30's float regulator mode will assume control. The float mode then supplies a gentle tapering finish charge to the battery allowing it to be maintained at a full charge just below the battery gassing point. (36-120 volt units do not have this "float mode" feature.)

Should any power be drawn from the battery at this point, the BVR-30 will supply it through the float regulator while continuing to charge the battery at a reduced rate. If the power drawn from the battery exceeds the float mode's rating therefore causing battery voltage to fall appreciably, the floating mode will cease and full charging will again resume to ensure full use of available power from the charging source.

BVR-30 ELECTRICAL SPECIFICATIONS

UNIT PARAMETER	UNIT VOLTAGE				
	12v	24v	36v	48v	120v
Charging current, (maximum)	30 amps	30 amps	30 amps	30 amps	5 amps
Load current, (maximum from load terminals)	30 amps	30 amps	30 amps	30 amps	30 amps
Charging source open circuit voltage, (maximum)	22 volts	44 volts	66 volts	88 volts	220 volts
Temperature range (operating)	0°C to 50°C	0°C to 50°C	0°C to 50°C	0°C to 50°C	0°C to 50°C
Current consumption (full charging)	.15 amps	.10 amps	.08 amps	.08 amps	.02 amps
Current consumption (floating)	.01 amps	.01 amps	.01 amps	.01 amps	.01 amps
High voltage charge termination threshold	14.8 volts (±.2)	29.6 volts (±.4)	44.4 volts (±.6)	59.2 volts (±.8)	148 volts (±2.0)
Full charge resumption threshold	12.5 volts (±.2)	25.0 volts (±.4)	37.5 volts (±.6)	50.0 volts (±.8)	125 volts (±2.0)
Floating voltage	13.1 volts (±.2)	26.2 volts (±.4)	—	—	—
Floating current, (maximum)	2 amps	1 amp	—	—	—

NOTE: For more in-depth technical information please request a Photron Technical Description Sheet for this product(s).

photron inc. 149 n. main st. willits ca. 95490 (707)459-3211
energy systems

Manufacturers and Distributors of Quality Alternative Energy Systems and Related Equipment

NOTE: Due to our continual efforts of product innovation and improvement, specifications given on this data sheet are subject to change without notice.

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Energy Systems
Installation Recommendations

IMPORTANT

PLEASE READ THESE RECOMMENDATIONS CAREFULLY BEFORE ATTEMPTING TO INSTALL OR OTHERWISE OPERATE YOUR PHOTRON BVR-30 (or 30M) REGULATOR.

WARNING

ELECTRICITY (EVEN LOW VOLTAGE ELECTRICITY) CAN BE VERY DANGEROUS. PHOTRON, INC. RECOMMENDS THAT ALL ELECTRICAL INSTALLATIONS - INCLUDING THE INSTALLATION OF THIS PRODUCT - BE PERFORMED BY LICENSED OR PROPERLY QUALIFIED INDIVIDUALS ONLY.

LOCATION

Mount the BVR-30 in an indoor area that is protected from wind, rain, excessive dust, moisture and heat as you would a standard household radio or TV.

The BVR-30 must be mounted vertically (the holes in the chassis flange are provided for this purpose) with its venting slots on the top and bottom so that cooling air may flow through the slots without obstruction.

Ideally the BVR-30 should be located near the battery it is protecting - but never confined within a sealed battery enclosure where hydrogen gas from normal charging might accumulate.

The BVR-30 terminals will accept up to #10 gauge wire or terminal lugs. If larger gauge wire is used, a down conversion to #10 is required. (This can be simply accomplished thru the use of a common "wire or twist nut", etc.) Be sure to anchor all wire that you connect to the BVR-30 terminal strip within one foot of the unit so that no stress is placed upon the strip itself.

WIRING

Note: When making wire connections to the BVR-30 be sure that the wires you are handling are fully de-energized. Failure to do so may cause severe bodily harm or permanent damage to the BVR-30.

Connect the BVR-30 to the rest of the system as shown in Figure 1. Use wire of sufficient size and current carrying capacity to prevent undue power loss and ensure proper operational safety for all connections. (The exception to this is for terminals #1 and #8. These may use #20 gauge or larger wire. When the BVR-30 is placed within 10 feet of the battery these terminals may be simply connected as follows: Connect terminal #1 to #2, and then connect terminal #8 to #7.)

Note: Do not exceed the Voltage and Current Ratings shown on the I.D. label at the bottom of the BVR-30 chassis or as listed on the BVR-30 product specification sheet.

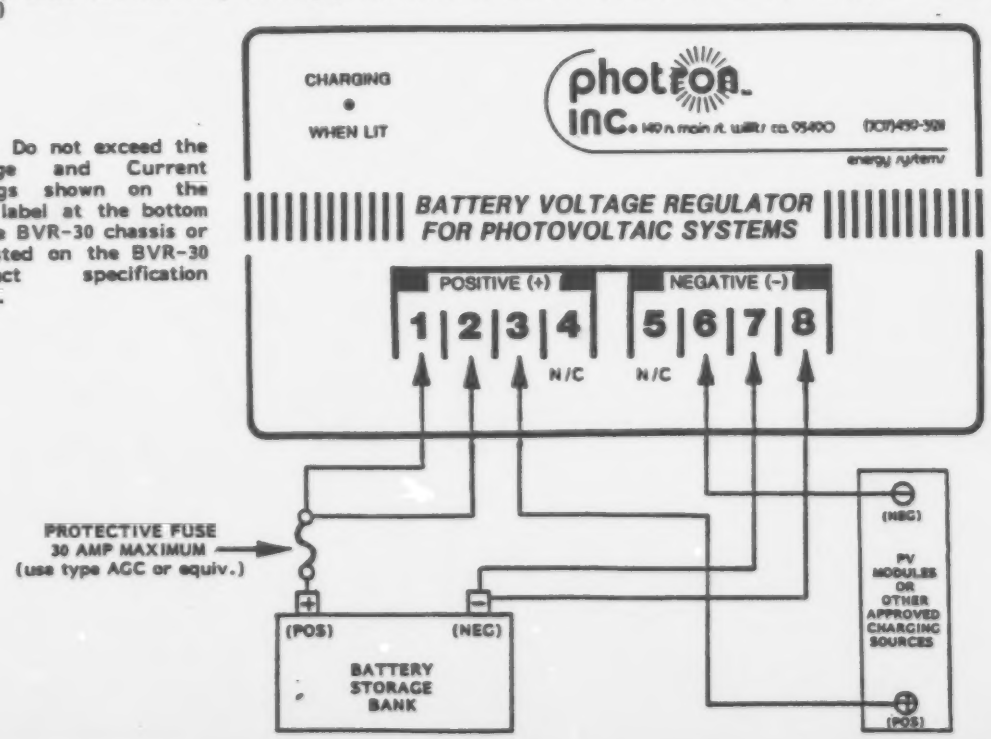

FIGURE 1

TERMINAL FUNCTIONS

The BVR-30 terminals are coded as follows:

- Terminals #1 and #8 are for battery voltage sensing.

  These are provided so that true battery voltage may be measured for BVR-30 control functions. These terminals are separate from the standard battery terminals (#2 and #7) so that readings will be uninfluenced by current flow.

- Terminals #2 and #7 are for battery charging output current flow.

  From these terminals current from the photovoltaic (PV) array or other approved charging source is supplied in a voltage regulated fashion to the battery that is connected to them.

- Terminals #3 and #6 are for PV array or other approved charging source input current flow.

  Into these terminals current from the PV array or other approved charging source flows. This current is voltage regulated and then provided as a charging output at terminals #2 and #7 (see above) for the system's battery.

Special Notes

1) The battery fuse depicted in Figure 1 is to be supplied by the user for the overcurrent protection of the charging circuit wires as well as the BVR-30 itself, should a short circuit occur on the charging source (or "input") side of the regulator.

   The fuse rating should be no greater than the current rating on the ID label of the unit, and lower than the maximum allowable current carrying capacity of the wire it is connected to.

2) During float charge (where applicable) the BVR-30 chassis may feel quite warm, this is normal.

3) Never perform a short circuit current test on the PV array (or individual modules) without first disconnecting and isolating terminal #3. Failure to do so may result in permanent damage to the BVR-30, and VOID THE WARRANTY.

4) If a problem with your BVR-30 should ever develop, observe the following procedure:

   1) Check the battery fuse (illustrated in Figure 1) to see if it is intact. If blown - replace it only after determining cause of original failure.

   2) Check all wiring connections for proper electrical polarity and continuity. Correct if necessary.

   3) If no obvious cause for the problem is discovered, call your local dealer for service. DO NOT OPEN UNIT CHASSIS - NO USER SERVICEABLE PARTS ARE CONTAINED WITHIN. (Failure to observe this will automatically void the BVR-30 warranty.)

   4) If adequate service is unobtainable contact Photron, Inc. at the phone number or address listed on the face of the unit.

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Now if the relay is closed after the first check, it will be forced open every two hours until the sun is down. The relay then stays open until the next sunrise, when the entire process is repeated.

An example: If the sun rises at 6 AM, the relay will be forced open at 4 PM. If the panels are still producing power, and the batteries need it, the relay will reclose. The relay will then be forced open every two hours until it stays open for the night.

The timer has no effect if the batteries are charged and the relay is already open. The timer has an effect only when the relay is closed.

It is possible that the relay may be energized for up to two hours after sunset. For instance, if the sun set at 8 PM and the timer forced the relay open at 7:45 PM (and the relay reclosed), the relay would not open again until 9:45 PM. Very little power will be lost during this time.

Finally, it is important to note that there can be a large variation in the actual times associated with the timer. The "10 HOUR" mode can vary by as much as 2 hours, and the "2 HOUR" mode can vary by as much as 1 hour.

3.7.0 DC SOURCE CENTRE

This unit is located in the upper left-hand corner of the power board and acts as a main disconnect switch for the entire service.

This switch should be pulled to the "off" position if at any time a malfunction occurs within the system that the home owner cannot identify and rectify immediately.

3.7.1 PV ARRAY DISCONNECT SWITCH

This unit is located immediately below the "DC source centre" on the left-hand side of the panel board.

This switch is used to disconnect the PV array from the

power system and should be normally in the "on" position but would be turned "off" in the case of malfunction of the array or work is required on the array itself.

Note this switch does not eliminate the electrical hazard existing from the power producing modules on the array during sunlight hours whether this switch is pulled or not. It isolates the control board from the array power but the cables to the array and the array terminal system will still be "live" if the sun is shining.

SECTION 3.8 BATTERY CHARGER

The charger unit is a "Photron Gen Charger unit P-24200" and is a heavy duty charger specifically designed to handle the input from gasoline driven generator sets. It feeds the power in the proper amount to the batteries so that the charge will be completed in the minimum amount of time. When the batteries are low more power is fed to the batteries and as the batteries become closer to their full charge the amount of power fed to the batteries is decreased for the most efficient operation.

The function of the generator charger is completely automatic and should require no attention by the occupant.

This unit receives the 240 volt input power up to a maximum of 25.8 amps and then converts it and feeds it to the batteries up to a maximum of 200 amp hours in charging a 24 volt battery. The charger can take the entire output of the generator set but will normally take only that portion which is not being used by other loads in the household circuit.

The battery charger switch position should always be left in the "on" position.

Note that once the generator has started there is a 3 minute warm-up time to reach a proper working condition for the generator before the battery charger itself will commence operation. This is not a malfunction. However, if the battery charger does not indicate output within 5 minutes a malfunction should be suspected.

As soon as the battery charger commences operation the

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Energy Systems

Installation Recommendations

THE GENCHARGER[tm]

IMPORTANT

PLEASE READ THESE RECOMMENDATIONS CAREFULLY BEFORE ATTEMPTING TO INSTALL OR OTHERWISE OPERATE THIS PHOTRON PRODUCT.

WARNING

ELECTRICITY (EVEN LOW VOLTAGE ELECTRICITY) CAN BE VERY DANGEROUS. PHOTRON, INC. RECOMMENDS THAT ALL ELECTRICAL INSTALLATIONS - INCLUDING THE INSTALLATION OF THIS PRODUCT - BE PERFORMED BY LICENSED OR PROPERLY QUALIFIED INDIVIDUALS ONLY, AND ALWAYS IN COMPLIANCE WITH LOCAL SAFETY AND ELECTRICAL CODES.

LOCATION

Install the GENCHARGER in an indoor area that is protected from wind, rain, excessive dust, moisture and heat, as you would a standard household radio or TV.

Ideally the GENCHARGER should be located as near to the battery it is to charge as possible - but never confined within a sealed battery enclosure where hydrogen gas from normal battery charging might accumulate. If for any reason the standard input and output leads supplied with the GENCHARGER must be lengthened to facilitate installation, be sure to use a properly sized heavier gauge conductor than that which is being lengthened. Failure to do so may significantly affect GENCHARGER operation. (For assistance in proper conductor sizing consult your local Photron dealer, or contact Photron's Service Desk @(707) 459-3211.) If desired, the GENCHARGER can be remotely controlled as described later.

Once an installation location is chosen, ensure that good access is provided to all GENCHARGER cooling vents or screens so that air flow into and out of the GENCHARGER cabinet is not restricted in any way. Always provide enough room around the front of the unit to allow its front panel door to be opened at least 90° outward in order to provide adequate room for GENCHARGER adjustment or fuse replacement, etc.

WIRING

Note: Before making electrical connections or any mechanical alterations to the GENCHARGER, always be sure that the unit is fully de-energized and disconnected from all DC (battery, etc.) and AC (generators, utility line, etc.) power sources. Failure to do so may cause severe bodily injury, or permanent damage to the GENCHARGER and void its warranty (not to mention your fingers!).

To place your new GENCHARGER into initial operation simply execute the following steps (refer to Figure 1):

1) With GENCHARGER Main Power Switch in the "Off" position connect the AC Input Power Line Cord to the desired AC power source (generator, utility grid, etc.) Be sure that the voltage and phase of the AC source you are connecting to is the same as that called for on the GENCHARGER's I.D. Label. (Failure to do so may damage the unit and void its warranty.) Because of the GENCHARGER's unique and adjustable design, the actual voltage of your particular AC source may vary from the spec number shown on the I.D. label somewhat. (Example: for 120 VAC units, any input voltage between 100-140 VAC is acceptable, etc.) Adjustments will be made for these variances in the steps which follow.

SPECIAL NOTE: If your charger was not supplied with an AC Line Cord (this is standard practice on GENCHARGERS which require over 30 amps of peak AC input power) it must be hardwired to its AC power source. In this case proceed as follows before going on to step #2:

a) Using wire of sufficient current carrying capacity which is properly sized to avoid undue voltage losses, enter the GENCHARGER cabinet from the hole where the AC Line Cord would have been. (Be sure to use some form of strain relief clamp, such as a "Romex cable clamp" or equivalent, so that the cable is secured at the GENCHARGER AC Input hole.)

b) Connect either the hot and neutral (for 120 VAC input units) or the two hot leads (for 240 VAC input units) to the two AC Input Power Studs on the internal GENCHARGER Control Panel. The third (ground) wire should then be securely connected to the GENCHARGER chassis. (The mounting screw for the AC Power contactor or Spare DC Output Fuse are both convenient places to do this - the contactor location being prefereble when available.) Use of proper wire terminations such as "ring or spade lug" terminals is highly recommended for all of these hardwire connections.

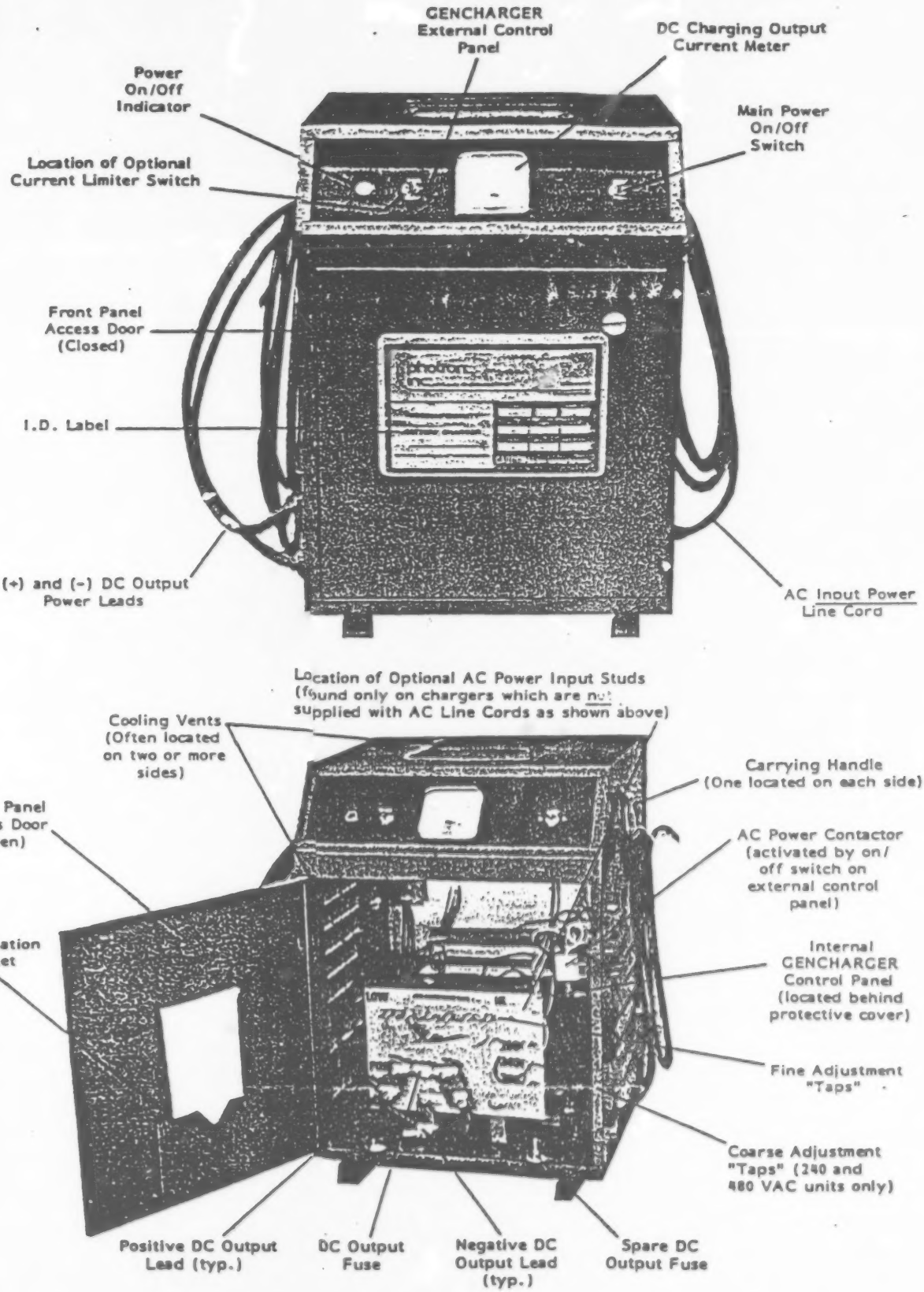


FIGURE 1: GENCHARGER FEATURES AND LAYOUT

2) Ensure that the DC Output Voltage of your GENCHARGER unit (found on I.D. label) properly matches (within roughly ±20%) the voltage of the battery to be charged. Then connect the GENCHARGER's DC Output Power Leads to the battery, being careful to observe the proper electrical polarity. [E.g. connect the positive (+) lead (marked with red band) to the battery's positive (+) terminal, (or electrical equivalent, etc.) and the negative (-) lead (unmarked) to the battery's negative terminal (or electrical equivalent, etc.)] Your GENCHARGER may be connected to any size battery that has a capacity rating which is at least three times larger than the GENCHARGER's maximum DC current output (found on I.D. label).

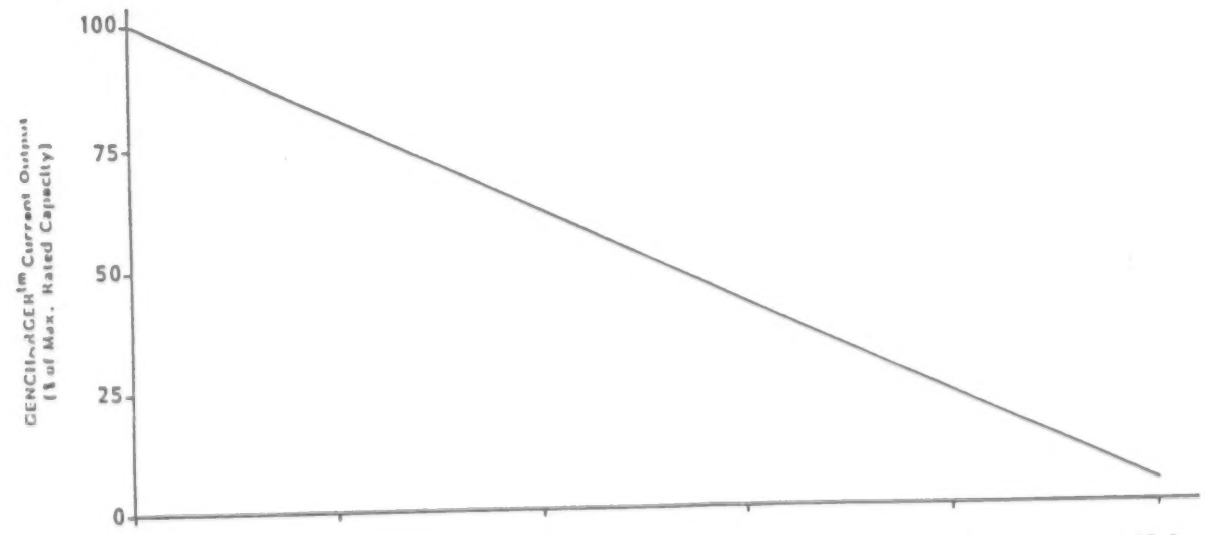
GENCHARGER FINE TUNING

3) After double checking all wiring connections, activate the AC power source, and then turn the GENCHARGER's Main Power Switch to the "on" (up) position. After the unit has been "on" for five minutes, measure and record the battery's voltage (taken at the battery terminals) with a standard voltmeter of 5% or better accuracy. Also record the DC output current as shown on the GENCHARGER's DC Charging Output Current Meter.

4) The numbers recorded from step #3 will now be used to custom fine tune your GENCHARGER's factory setting to your particular AC power source and overall power system conditions. (It is the GENCHARGER's special adjustment feature and hence this fine tuning procedure that is the secret to the GENCHARGER's unique ability to dramatically outperform all other standard type battery chargers.)

Using Figure 2, locate the voltage reading you found from step #3 on the horizontal line of the chart. Once you have located that point, trace a vertical line upwards until it intersects the sloping line on the chart. From the point of intersection trace a horizontal line over to the vertical line of the chart which is labeled as "Gencharger Current Output (In % of Max. Rated Capacity)," and record that number.

Multiply this number times the maximum rated output current for your charger (found on the I.D. Label), and divide the result by "100". Compare the number obtained from this procedure to that which was read from the GENCHARGER's output meter in step #3 above. THE OBJECT OF THE "FINE TUNE" IS TO OBTAIN A METER READING THAT IS 30% (1.3 TIMES) GREATER THAN THIS CALCULATED NUMBER.

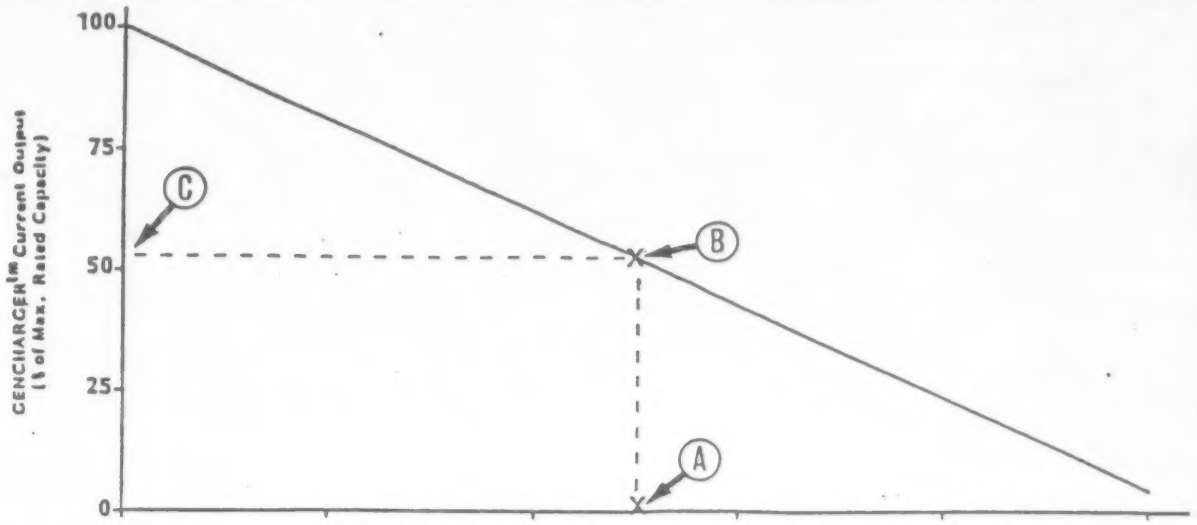


For 12 VDC Batteries:	12.0	12.6	13.2	13.8	14.4	15.0
" 24 " "	24.0	25.2	26.4	27.6	28.8	30.0
" 36 " "	36.0	37.8	39.6	41.4	43.2	45.0
" 48 " "	48.0	50.4	52.8	55.2	57.6	60.0
" 120 " "	120.0	126.0	132.0	138.0	144.0	150.0

- BATTERY VOLTAGE READ IN STEP #3 -

FIGURE 2: TYPICAL GENCHARGER™ CURRENT OUTPUT VS. BATTERY VOLTAGE

For Example: (Refer to Figure #3) Let's say that you have a 24 VDC charging system, have measured a battery voltage of "27.0" (volts), and noted a GENCHARGER meter reading of "50" (amps). Referring to Figure 3, locate "27.0" on the horizontal axis of the chart. (Note that this is halfway between "26.4" and "27.6" @ point "A".) Trace a line up vertically until you hit the sloping line of the chart, (@ point "B") and then trace over horizontally to our left until you reach the chart's vertical axis (@ point "C"). The value found at this point is roughly "55". Checking the maximum output current rating on the label of the imaginary GENCHARGER you find its value to be "125" (amps).



For 12 VDC Batteries:	12.0	12.6	13.2	13.8	14.4	15.0
" 24 " "	24.0	25.2	26.4	27.6	28.8	30.0
" 36 " "	36.0	37.8	39.6	41.4	43.2	45.0
" 48 " "	48.0	50.4	52.8	55.2	57.6	60.0
" 120 " "	120.0	126.0	132.0	138.0	144.0	150.0

- BATTERY VOLTAGE READ IN STEP #3 -

FIGURE 3: SAMPLE EXERCISE FOR "FINE TUNING" PROCEDURE

Now that you have all the numbers needed for the fine tuning calculation, simply plug them in and find the magic number that you want to see on the GENCHARGER's output meter for this particular situation. Therefore:

$$[(\text{"55"} \times \text{"125"}) \div 100 \times 1.3 = \boxed{89}$$

Comparing the magic number of "89" (amps) to the value of "50" which was originally read from the GENCHARGER's output meter it is found that things are less than optimum! Basically, what this tells you is that the GENCHARGER is not putting out as much POWER as it could be, due to various circumstances which are unique to this particular imaginary system. The solution? Adjust the GENCHARGER!

5) Making fine tune adjustments on your GENCHARGER is simple, and is accomplished as follows:
- Turn the GENCHARGER main power switch off.
- Disconnect the GENCHARGER from all AC and DC sources of power (e.g. generators, batteries, et al., etc.)
- With all power removed from the unit, open the Front Panel Access Door and locate the row of Fine Adjustment Taps. This is a series of threaded studs which protrude, through the Internal GENCHARGER Control Panel. You'll note that one of the studs has a small "jumper wire" bolted to it; (this wire then disappears into the panel). By removing the nut from this stud, taking the "tap jumper" off it, and then rebolting it onto the next stud to its right - you will automatically increase the GENCHARGER's power output. (Conversely - going in the other direction reduces power output.)
- With this new "tap setting" in place, close the access door and reconnect the battery to the unit. Then reactivate the AC power source (if necessary) and turn the Main Power Switch on.
- After five minutes has passed, take the readings discussed in step #3 once again.
- With these new readings, repeat the calculation procedure explained in step #4.
- If the "magic number" roughly matches the meter reading, the "fine tuning" procedure is complete. If it does not match, repeat step #5 (and then #3 and #4, etc.) until it does. Should the last tap stud be reached, and a still higher adjustment be desired - it will then be necessary to make a "Coarse Tap" adjustment. [Note - coarse taps are not generally available on 120 VAC units. If you have a 120 VAC unit which requires this adjustment - first check your AC input power voltage at the unit while it is charging. If this voltage is under 120 VAC, try to bring it up to 120. (With engine generators this is often done through governor adjustment, etc.) If the situation cannot be corrected, contact your local dealer or Photron for assistance.]
- To make a coarse tap adjustment, you simply proceed as you would when making a fine tap adjustment, (e.g. disconnect unit from all sources of power, etc.) except that you'll be changing one of the coarse tap positions on the right of the control panel. (Refer to Figure 1) Moving the tap jumper downwards (say from the point labeled "240" to "208") increases GENCHARGER output power significantly and vise versa. Note that making a coarse tap adjustment often means that the fine taps must be backed down somewhat (from the last tap on the right) in order to ensure a proper tune for your GENCHARGER.

WARNING

DO NOT TUNE YOUR GENCHARGER TO PUT OUT MORE POWER THAN DIRECTED IN STEP #4. "OVER-ADJUSTMENT" MAY CAUSE GENCHARGER DAMAGE, DC OUTPUT FUSE BLOWING, AND SEVERE BATTERY OVERCHARGING. ER-ADJUSTMENT WILL VOID YOUR GENCHARGER WARRANTY.

✪ SPECIAL APPLICATION NOTE ✪

WHERE A GENCHARGER IS INSTALLED WITH ITS AC INPUT POWER COMING FROM AN ELECTRICAL UTILITY COMPANY, AND IS USED TO CONTINUOUSLY FULLY CHARGE THE BATTERY IT IS CONNECTED TO (SUCH AS IS THE CASE IN LINE TIED UPS SYSTEMS, ETC.), THE OBJECT OF FINE TUNING IS TO OBTAIN A METER READING THAT IS EQUAL TO THE CALCULATED NUMBER WITHOUT THE 30% (1.3 TIMES) INCREASE DISCUSSED IN STEP #4.

In other words rather than the magic number of "89" we were looking to see on the meter (55 X 125 ÷ 100 X 1.3 = [89]), we would be looking for "69" (55 X 125 ÷ 100 = [69]). The change in tuning procedure for this particular application is made in order to prevent battery overcharging and excessively high battery terminal voltages at the end of the charge cycle.

6) Though GENCHARGER fine tuning is now complete, it is a good idea to check the adjusted unit again sometime when the battery is very low in charge (unless the original adjustments were made under this condition).

Always repeat the tuning procedure if the AC input power source is changed or altered (a new engine generator is installed, etc.).

GENCHARGER OPERAT ON

Once properly installed, your GENCHARGER will efficiently charge your system's batteries without need for any user ttention due to its special all solid state self-regulating design which provides a smooth, tapering charge output.

Where the GENCHARGER is connected to the utility line for its AC input power, users should manually turn the GENCHARGER switch on and off as charging is desired, or employ Photron's automated SENTRY™ control to do that for them.

When the GENCHARGER is powered by an engine generator, the unit's main power switch should be left in the "on" position to allow for charging whenever the engine generator is activated.

For those who wish to control the operation of their GENCHARGER from a remote location, the main power on/off switch may be removed from the unit's External Control Panel and have its leads lengthened (using #18 gauge wire) so that it may be placed in any convenient location desired.

GENCHARGER MAINTENANCE

7) Once tuned, your GENCHARGER will never require any further maintenance whatsoever, performing perfectly for the life of your power system, under normal conditions.

Should a problem with operation ever develop, observe the following check-out and repair procedure: (Remember to perform all operations that do not require running of the unit, with unit fully de-energized and electrically isolated from all sources of power.)

A) GENCHARGER IS "ON" BUT PUTS OUT NO POWER (METER READS "0"):
- Check for low AC input voltage condition, correct if necessary.
- Check for blown DC output fuse, replace only after discovering reasdn for original failure (see item "D" below).
- Check connection to battery for loose, open or resistive conditions, correct as necessary.
- Check internal DC output lead connection for loose or open contact, correct as necessary.
- Check DC output meter for proper operation (if it has failed for any reason - the charging current will not be represented upon it, although unit may otherwise be fully operational). Replace if necessary.
- Check for proper GENCHARGER 'tune" (refer to step #3 above), readjust if necessary.
- Check system's battery for abnormal characteristics (it may be overly resistive or have an internal open circuit), replace if necessary.

B) GENCHARGER IS "ON", BUT PUTS OUT VERY LITTLE POWER:
- Check for proper GENCHARGER "tune" (refer to step #3 above), readjust if necessary.
- Check for low AC input voltage condition (while unit is "on" and charging), correct if necessary.
- Check DC output lead connection to battery, battery system's own interconnections, or internal DC output lead connection to GENCHARGER internal control panel, etc. for poor or resistive electrical contact.

C) GENCHARGER PUTS OUT TOO MUCH POWER WHEN "ON" (DC OUTPUT FUSE MAY BLOW):
- Check for proper GENCHARGER "tune" (refer to step #3 above), readjust if necessary.
- Check for high AC input voltage condition, correct if necessary.
- Check system's battery for abnormal characteristics (it may be partially shorted externally or internally, or be improperly wired, etc.), correct as necessary.

D) DC OUTPUT FUSE BLOWS:
- Check for short circuit condition on or in battery, or same on DC output leads, or improper battery wiring, correct if necessary.
- Check for improper (too high) GENCHARGER tune (refer to step #3 above), adjust lower if necessary.
- Check for excessively discharged battery. [If found, set all coarse and fine taps to their lowest settings (fine tap to far left on "LO", and coarse tap, if present, to upper position or "260", etc.) and recharge battery to a full charge condition. After a full charge, re-tune GENCHARGER per steps #3-5 above.]

E) EXTERNAL AC FUSE OR CIRCUIT BREAKER ON AC INPUT POWER SUPPLY SOURCE BLOWS:
- Turn GENCHARGER's main power switch to "off" (down), and then disconnect unit from the battery it's charging. With AC input power source activated, turn GENCHARGER "on". If AC source fuse or breaker blows again, check for short circuit between that fuse and the GENCHARGER. If no short is found the GENCHARGER probably has an internal rectifier failure - call for service.

Should AC fuse not blow, turn GENCHARGER power switch "off", and then reconnect battery. Check current rating of AC fuse or breaker and ensure that it is at least 1.3 times (30%) greater than the peak AC input current rating found on the I.D. label of your unit. (When altering any such branch circuit overcurrent protection device, take care not to employ a device whose continuous rating is greater than that of the circuit it must protect.) If its rating is at least 30% greater, readjust GENCHARGER's power output per step #5, downward.

F) LIGHTS FLICKER WHILE GENCHARGER IS "ON":
- This is a normal occurrence on systems where large chargers are used to charge relatively small battery capacities (hence, systems where very high charge rates are employed). No danger is present. If the phenomenon is annoying and therefore deemed unacceptable, simply adjust the GENCHARGER's output power downwards per step #5 above, or increase system battery capacity.

G) GENERATOR "BOGS DOWN" (LOSES RPM) OR STALLS COMPLETELY:
- Check generator to ensure that it is properly rated to power your GENCHARGER. (See "GENCHARGER Selection Tips" on the Photron GENCHARGER product brochure for assistance.) If it is not, either adjust GENCHARGER output power downwards, or install a larger generator or smaller GENCHARGER.
- If generator is properly rated for your GENCHARGER, it may require general servicing (engine tuning or overhaul) or a simple voltage regulator/engine speed governor adjustment. (Refer to the generator service manual for further information.)

IF YOUR PARTICULAR PROBLEM CANNOT BE CORRECTED THROUGH ATTENTION TO ONE OF THE PRECEDING PROCEDURES - CONTACT YOUR LOCAL DEALER OR PHOTRON, INC. FOR ASSISTANCE.

⇨ SAVE THESE RECOMMENDATIONS FOR FUTURE REFERENCE ⇦

(The information pocket on the inside of the GENCHARGER's Front Panel Access door is provided for this purpose.)

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7/21/88

red light on the left-hand side of the panel will light up and the dial indicator will show the amount of current in amps that is being fed to the batteries as a charge.

SECTION 3.9 GENSET

The generator set is a Honda model EX5500 as described in the attached sheet. It is a liquid cooled 4 stroke twin cylinder engine similar to a car engine that does not require oil added to the gasoline. The oil level in the crank case must be checked in regular routine maintenance according to maintenance instructions in the manual.

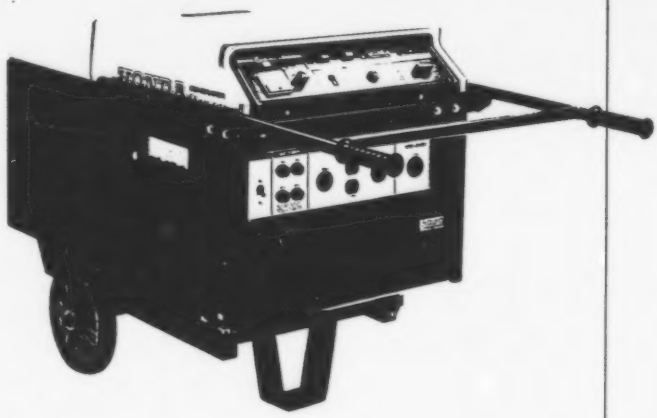
The fuel is standard leaded gasoline as used in cars, and boats and the operation of the generator set will normally be automatic. It can be manually started and in the event that the failed genstart light alarm shows on the gen wizard controller, a manual start may be required. You should familiarize yourself with the necessary procedures to manually start the generator.

The generator puts out electrical power of 240 volts, 60Hz which is fed into the control panel and reduced to 120 volts for use in the household circuits. Power produced by the generator that is not used in the household circuits is fed through the battery charger into the batteries and stored for later use.

Should the oil level in the engine of the generator become too low there is an automatic function which will stop the engine before damage is done to the internal components of the engine. This should be checked should the generator fail to start or stop functioning before the battery charge is complete.

Note that the "oil" warning light on the gen set panel has been disconnected and the bulb removed to avoid discharging the gen set starter battery while in the standby mode. The low oil shutdown feature described in the previous paragraph will however still function.

EX5500



As an auxiliary power supply for office and domestic use, the extremely refined EX5500 boasts technology found in few other generators. Its 5500 watts come from an advanced OHC twin-cylinder engine that's liquid-cooled for amazingly silent operation and long engine life. Not to mention superb fuel efficiency–up to 33 percent better than air-cooled engines of similar output. Anti-vibration rubber pads and other noise-damping features also help make it one of the smoothest, quietest generators on the market.

FEATURES:

- ☐ rugged, dependable Honda four-stroke twin-cylinder liquid-cooled engine
- ☐ underframe and hanging hook for easy loading and transportation
- ☐ automatic throttle saves gas when power demand is low
- ☐ automatic choke facilitates starting
- ☐ automatic voltage regulator assures steady output
- ☐ voltmeter
- ☐ fuel gauge shows remaining fuel at a glance
- ☐ Oil Alert system stops engine before oil drops too low
- ☐ CD electronic ignition cuts maintenance
- ☐ extra-quiet muffling keeps noise to a low 63 dB.A. @ 7 m

SPECIFICATIONS EX5500

AC Output	
Max. (Watts)	5500
Rated (Watts)	5000
Rated (Amperage)	41/21
Frequency (Hz)	60
Voltage (Volts)	120/240
Dimensions/Length	914 mm (36.5 in.)
Width	584 mm (23.0 in.)
Height	700 mm (27.6 in.)
Dry Weight	180 kg (396.9 lbs)
Engine Type	Liquid-cooled, twin cylinder
Displacement	359 cc
Fuel Tank Capacity	16.0 litres
Operational Capacity Per Tankful* Approx.	5.2 hours
Fuel Consumption (Rated) L/Hr.	3.1
Special Features	Extra quiet (63 dB.A. @ 7 m) Oil Alert, CDI, Automatic choke, Voltage adjuster Auto throttle, Box frame Electric start
Optional Equipment	Remote start kit

*Estimate only, based on rated load.

All specifications subject to change without notice.

SECTION 3.10 MONITORING

The performance monitoring system in the house is supplied by Adkinson & Associates and is installed temporarily to record the performance of the power generating system and is not intended for a permanent installation. The main unit of the monitoring system is the 21X Campbell Scientific Micrologger which receives input from the various sensors and records it electronically on a cassette tape recorder automatically. The tapes from the recorder should be removed the last day of each month and forwarded in the mailing envelopes to Adkinson & Associates.

The sensors for the monitoring system are located on the array and generator shed for sensing the sun and temperature, on the batteries and on the control panel in the form of power meters and current shunts. None of these sensors will normally require attention by the occupant.

APPENDIX B

Performance Monitoring Reports

TROUT LAKE - MONTHLY REPORT 2
SUMMARY OF ENVIRONMENTAL PARAMETERS Aug 1-31/87
mr2

Day	G Solar kWh/m2 IGt	T Solar kWh/m2 IAt	Ta Mean deg C	Ta Max deg C	Ta Max Time of	Ta Min deg C	Ta Min Time of	G Solar MaxInst IG	T Solar MaxInst IA
Day 213 = Aug.1									
214	2.715	4.1224	13.67	18.88	147	10.93	1639	657.09	1049
215	4.3298	5.6086	15.47	21.1	806	10.57	1843	648.28	977.74
216	4.2193	5.7998	16.17	22.11	450	12.24	1600	727.82	962.76
217	2.9686	4.9701	17.55	23.33	236	13.06	2005	830.73	959.62
218	2.9322	3.0031	14.2	19.49	444	10.27	1430	918.59	971.94
219	2.1554	1.9139	12.19	18.2	301	8.37	1744	917.35	943.34
220	3.7333	4.0749	10.75	16.29	405	2.701	1732	974.32	1113.1
221	3.748	4.1331	10.39	14.43	304	7.62	2004	839.77	1180.8
222	2.4107	2.7523	9.61	12.15	531	8.23	3	760.88	929.57
223	4.3922	5.5895	9.78	14.91	632	1.796	1800	844.85	1071.8
224	4.7001	6.5464	8.41	16.56	0	1.65	1834	939.72	994.08
225	3.4039	3.5862	13.27	20.12	423	6.654	1837	1057.8	1086.3
226	4.583	5.9615	13.16	17.36	408	10.26	1841	854.15	1042.9
227	4.0242	5.7917	12.41	17.9	350	7.03	1322	727.4	945.87
228	4.3249	5.3733	13.94	18.93	402	9.38	1745	834.14	982.34
229	3.6476	5.6306	11.95	16.6	417	4.787	1727	862.32	1237.2
230	3.7707	5.0536	14.72	19.3	403	11.82	2035	666.32	948
231	3.373	5.5881	10.16	16.17	303	2.094	1849	651.33	907.01
232	3.7734	6.5849	11.4	16.67	2352	4.346	1906	604.24	945.11
233	3.5965	6.1216	12.92	20.6	240	3.938	1850	754.83	941.96
234	3.8635	5.9578	15.6	21.97	351	10.68	1949	687.95	936.52
235	3.637	6.4774	12.25	18.37	350	4.009	1740	664.53	1019.2
236	3.8303	6.4646	15.03	22.53	358	6.29	1905	691.13	914.5
237	3.4007	4.4853	17.13	23.27	404	12.77	2243	632.17	906.28
238	1.1	2.4637	11.22	13.63	29	9.23	1849	428.28	881.48
239	2.0416	3.206	9.15	14.23	341	2.225	1813	687.51	1073.3
240	3.0749	4.349	12.5	15.86	433	10.17	1428	841.39	1109.2
241	1.2345	1.9968	1.928	15.74	3	-1.237	1951	541.76	962.7
Day 243 = Aug.31									
Total	95.0	133.6							
Average	3.4	4.8	12.4	18.1		7.2		732.6	999.8
Maximum	4.7	6.6	17.6	23.3		13.1		1057.8	1237.2
Minimum	1.1	1.9	1.9	12.2		-1.2		0.0	881.5

TROUT LAKE - MONTHLY REPORT 2/SUMMARY OF ENVIRONMENTAL PARAMETERS June 1-30/87/mr2

Day	G Solar kWh/m2 IGt	T Solar kWh/m2 IAt	Ta Mean deg C	Ta Max deg C	Ta Max Time of	Ta Min deg C	Ta Min Time of	G Solar MaxInst IG	T Solar MaxInst IA
June 1 = day 152									
152	2.5483	2.3193	7.21	16.28	202	2.327	2030	1045.2	1063.2
153	2.6233	1.8123	5.156	7.62	805	2.911	9	459.14	350.3
154	4.7854	4.1906	6.465	13.65	739	-0.492	1615	1023.4	1008
155	2.0061	1.4702	9.59	14.61	359	5.815	1918	353.17	263.61
156	2.7444	3.1571	6.611	13.97	2300	2.87	1316	744.14	841.11
157	6.0532	6.5363	14.34	23.05	723	4.791	1719	817.16	882.32
158	5.0692	5.9481	19.39	26.63	704	10.53	1705	761.26	871.81
159	3.2598	4.1537	15.81	26.09	242	8.74	1011	884.05	857.54
160	5.5739	6.0405	15.39	22.74	726	8.14	1801	1049.2	980.62
161	5.1025	5.5133	15.72	22.55	450	8.13	1722	1105.2	1034.1
162	5.4585	5.386	14.17	21.04	357	8.27	1711	1007	1039.5
163	6.0195	6.7321	11.95	21.56	323	3.948	1838	895.03	1034
164	4.8027	4.5335	10.24	18.25	733	2.58	1721	1075.2	1090.3
165	2.657	2.4715	9.25	16.1	630	4.098	826	839.85	893.79
166	4.0886	4.278	10.57	21.25	725	3.724	9	1148	1023.5
167	6.104	6.3638	14.67	20.77	739	10.47	1817	825.26	886.9
168	5.7174	6.3332	14.87	20.91	722	9.49	1819	1066.9	1048.3
169	5.842	6.4477	14	22.1	738	4.151	1652	830.8	925.53
170	5.352	5.3358	18.34	28.89	749	7.2	1743	782.78	884.05
171	1.7493	1.3229	17.08	24.67	743	12.41	2322	768.47	344.98
172	1.7609	1.4879	11.45	12.75	2345	10.29	2104	978.77	957.46
173	4.3762	4.9591	11.42	15.56	722	7.74	1616	1014.7	981.51
174	5.9064	6.593	16.5	22.45	705	11.37	1845	860.84	955.31
175	5.4343	5.3624	16.2	23.06	720	12.33	1508	966.99	1019.9
176	4.7655	5.882	15.88	22.76	245	10.93	1655	1094.7	941.53
177	5.2492	5.6629	15.66	22.61	723	6.286	1550	984.45	1048.6
178	3.8436	4.7455	19.07	26.12	431	13.22	1808	892.89	1024.9
179	5.0703	5.0675	17.09	28.27	750	7.83	1704	864.75	959.8
Total	124.0	130.1							
Average	4.4	4.6	13.4	20.6		7.1		897.8	900.4
Maximum	6.1	6.7	19.4	28.9		13.2		1148.0	1090.3
Minimum	1.7	1.3	5.2	7.6		-0.5		353.2	263.6

TROUT LAKE - MONTHLY REPORT 2
SUMMARY OF ENVIRONMENTAL PARAMETERS May 1-31/87
mr2

Day	G Solar kWh/m2 IGt	T Solar kWh/m2 IAt	Ta Mean deg C	Ta Max deg C	Ta Max Time of	Ta Min deg C	Ta Min Time of	G Solar MxInst IG	T Solar MaxInst IA
May 1 = day 121									
119	4.0754	4.5256	9.23	17.07	329	1.749	1847	693.14	955.54
120	3.4658	3.9602	11.15	20.39	421	4.899	1832	856.11	917.95
121	5.5175	6.8672	9.09	14.67	204	1.7	1744	794.25	990.03
122	5.2351	5.9152	9.03	16.34	439	1.823	1250	876.9	1032.5
123	4.8087	5.5509	7.29	11.88	2359	3.721	1712	890.34	1072.3
124	5.4229	6.6911	7.18	13.05	214	-0.367	1856	902.86	953.82
125	5.3665	6.254	11.1	16.63	549	4.45	1815	813.79	1062.8
126	5.6532	6.6177	5.197	11.86	222	-0.662	1616	766.17	971.81
127	5.5134	6.8678	4.124	10.43	513	-1.505	1839	835.79	1025.9
128	4.803	5.5156	3.618	12.19	254	-3.118	1700	966.23	1094.3
129	5.2019	5.9136	2.326	10.83	258	-3.858	1804	896.27	1072.8
130	1.534	1.4514	2.531	10.45	347	-3.112	2326	577.23	652.17
131	0.34262	3.7476	-3.356	1.924	2310	-10.01	1801	78.663	967.47
132	3.7334	5.3568	1.982	9.14	759	-1.784	2004	980.57	1150.1
133	3.8879	4.4657	-1.19	3.68	130	-4.291	1843	878.24	1220.7
134	5.0046	5.3733	1.645	5.33	2343	-1.012	49	916.01	1240.3
135	5.1364	5.4625	4.43	11.14	337	0.93	1745	929.13	1029.7
136	5.3119	5.2293	2.832	7.19	744	-3.489	1745	885.76	1045
137	5.4658	5.4492	0.681	6.823	526	-6.51	1757	998.54	998.52
138	5.1262	5.6625	4.905	13.54	2354	-3.434	1723	859.3	1059.3
139	6.0013	6.6773	10.76	19.16	722	3.367	1753	777.37	910.04
140	5.6135	6.0598	11.05	22.33	428	1.126	1759	834.64	926.57
141	4.4681	4.6752	10.66	18.47	725	5.994	1309	811.16	886.79
142	5.3047	5.9664	13.6	22.04	422	4.938	1809	830.71	873.54
143	5.0558	5.4234	9.13	15.62	110	3.535	1841	1003.6	1055.3
144	4.6415	5.3375	8.79	16.98	751	0.198	1749	937.4	1075.4
145	4.5893	4.93	14.45	22.46	703	5.946	1713	1010.1	1038.9
146	4.5076	5.2392	10.86	23.04	750	2.2	1717	853.72	975.84
147	5.6377	6.3548	15.34	25.33	712	7.56	2201	795.86	927.09
148	4.985	4.5157	15.14	24.37	353	7.99	1841	938.17	967.54
149	3.9286	3.9021	10.69	17.99	726	5.087	1744	1162.9	1133.5
150	4.3048	4.0728	9.63	13.6	505	6.259	2245	1021.9	913.91
Day 151 = May 31									
Total	149.6	170.0							
Average	4.7	5.3	7.3	14.6		0.9		829.5	1006.2
Maximum	6.0	6.9	15.3	25.3		8.0		1162.9	1240.3
Minimum	0.3	1.5	-3.4	1.9		-10.0		0.0	652.2

TROUT LAKE - MONTHLY REPORT 2
SUMMARY OF ENVIRONMENTAL PARAMETERS Apr. 1-30/87
mr2

Day	G Solar kWh/m2 IGt	T Solar kWh/m2 IAt	Ta Mean deg C	Ta Max deg C	Ta Max Time of	Ta Min deg C	Ta Min Time of	G Solar MaxInst IG	T Solar MaxInst IA
Day 91 = April 1									
89	0.9127	1.8215	-2.905	5.017	835	-8.81	1847	486.33	1003.5
90	3.3708	5.5876	2.554	8	2344	-2.512	1612	601.36	1037.9
91	2.2119	2.2683	-7.6	7.86	321	-15.17	2030	614.91	819.48
92	2.256	3.2812	-10.08	-7.12	446	-13.8	2214	516.23	1049.3
93	3.8514	7.512	-1.149	6.359	2350	-9.48	6	599.41	1111.4
94	3.7051	5.9289	0.542	8.71	308	-7.03	1825	750.87	1146.4
95	2.7553	3.3706	-0.454	4.094	825	-4.344	2152	536.73	866.41
96	1.946	1.7416	-3.149	2.062	159	-7.78	1934	358.73	333.09
97	1.8153	1.8494	-7.1	-4.037	0	-10.77	1536	237.92	251.07
98	2.1065	1.7633	-0.786	1.742	2348	-4.464	25	315.63	267.6
99	2.0698	2.1059	-4.49	2.128	20	-9.24	1613	526	532.04
100	3.6158	4.9824	-5.604	-1.085	656	-8.37	2015	882.71	1319.6
101	2.8544	3.1841	-4.692	1.283	0	-7.73	1857	690.51	952.41
102	4.6517	7.674	3.128	8.76	2357	-3.641	1648	739.45	1167
103	4.4579	6.4727	5.983	10.68	559	0.586	1811	684.92	1026.5
104	4.0379	5.161	2.637	6.967	415	-3.485	1838	803.1	1129.2
105	3.204	3.6839	3.418	8.36	149	0.006	2301	950.15	1088.1
106	2.849	2.49	-1.327	3.152	536	-6.092	1456	502.65	624.88
107	4.0338	4.9275	-4.068	1.904	0	-10.21	1842	742.5	1051
108	4.4304	6.1093	2.336	7.68	2326	-4.464	1911	869.81	1123.4
109	4.9233	6.712	2.009	9.65	351	-5.024	1912	845.16	1100.4
110	4.3844	5.9099	3.117	7.69	304	-0.376	1749	871.97	1092.7
111	5.094	6.7793	2.081	7.97	455	-5.079	1833	789.35	1014.7
112	4.7677	6.1068	1.621	9.84	349	-5.365	1904	680.35	951.79
113	4.9873	6.3479	5.551	11.86	521	-0.511	1805	711.1	927.6
114	4.0231	4.8517	4.115	10.72	511	-1.034	1458	673.64	915.96
115	5.2944	6.5317	6.324	10.38	352	1.391	1832	702.82	996.77
116	3.7824	4.0986	3.494	9.71	517	-2.531	1759	892.19	1140.9
117	4.0585	4.4077	6.774	13.26	412	0.119	1718	750.74	1005.8
118	3.2184	3.493	3.861	12.51	133	-2.26	1812	575.07	823.32
Day 120 =April 30									
Total	105.7	137.2							
Average	3.5	4.6	0.2	6.2		-5.2		642.0	929.0
Maximum	5.3	7.7	6.8	13.3		1.4		950.2	1319.6
Minimum	0.9	1.7	-10.1	-7.1		-15.2		0.0	251.1

TROUT LAKE - MONTHLY REPORT 2
SUMMARY OF ENVIRONMENTAL PARAMETERS Jan. 1-31/87
mr2

Day	G Solar kWh/m2 IGt	T Solar kWh/m2 IAt	Ta Mean deg C	Ta Max deg C	Ta Max Time of	Ta Min deg C	Ta Min Time of	G Solar MaxInst IG	T Solar MaxInst IA
6	13.19	73.731	-1.622	1.235	2137	-8.64	137	10.383	0
7	9.6368	40.348	.565	1.859	1532	-2.998	213	10.804	0
8	7.4964	20.924	-4.869	-.106	1	-9.81	911	9.8381	0
9	7.7215	23.171	.175	5.451	1938	-5.605	2	11.162	14828
10	15.286	79.646	.44	3.95	305	-6.07	2159	11.12	0
11	5.2979	7.9882	-7.62	-3.686	559	-11.82	2352	3.1596	0
12	5.759	9.0641	-17.69	-11.55	15	-27.79	2341	2.2097	0
13	15.707	69.976	-25.05	-17.9	1540	-30.15	404	11.191	0
14	19.164	83.369	-21.21	-8.71	2359	-29.64	844	11.61	0
15	11.347	52.398	-11.22	-7.69	1339	-15.65	2223	11.459	0
16	5.5733	6.0238	-13.76	-5.96	2306	-21.87	722	.98067	0
17	5.8971	5.6386	-9.24	-4.133	1516	-13.29	2214	1.1483	0
18	12.468	38.415	-8.69	-3.39	1550	-12.96	1200	9.8674	0
19	6.4009	6.9871	-10.43	-2.134	2258	-17.91	928	1.0161	0
20	8.5936	24.763	-5.28	-1.466	540	-12.39	2327	12.484	0
21	19.093	97.585	-14.62	-5.453	1614	-19.21	1010	12.294	0
22	18.231	97.682	-17.44	-9.16	1658	-21.71	1005	12.406	0
23	18.682	98.538	-17.22	-6.746	1623	-21.08	1006	12.385	0
24	12.147	38.253	-16.25	-10.76	1358	-19.73	1034	10.454	0
25	10.144	15.969	-13.84	-11.28	1719	-17.62	524	9.5719	0
26	9.0955	9.7251	-12.25	-10.18	1446	-15.89	119	1.2783	0
27	17.104	23.696	-13.98	-7.03	1624	-20.73	2339	9.7808	0
28	6.8019	5.5498	-6999	-13.76	336	-6999	2352	.7326	99999
29	15.704	34.742	-6999	171.2	41	-6999	1	7.1147	99999
30	9.9899	11.663	-6999	-25.53	819	-6999	2	1.7647	99999
31	8.4606	46.401	-28.35	-20.92	2110	-34.03	713	14.826	0

TROUT LAKE - MONTHLY REPORT 2/SUMMARY OF ENVIRONMENTAL PARAMETERS Dec. 1-31/86/mr2

Day	G Solar kWh/m2 IGt	T Solar kWh/m2 IAt	Ta Mean deg C	Ta Max deg C	Ta Max Time of	Ta Min deg C	Ta Min Time of	G Solar MaxInst IG	T Sola MaxInst IA
334	1.5329	6.5944	-3.872	0.286	1530	-13.33	110	11.725	670.71
335	1.3367	7.8401	-15.43	-7.46	1	-21.55	2358	10.593	274.57
336	1.6425	7.0046	-8.88	-3.137	1856	-21.52	4	12.219	0
337	0.66125	1.5637	-9.88	-2.819	420	-15.73	2323	5.7634	0
338	0.56105	0.64968	-18.27	-13.6	1550	-24.55	1123	1.1073	0
339	0.60439	0.99976	-18.64	-13.29	1541	-24.35	407	3.9042	160.6
340	0.25384	0.26884	-13.47	-8.45	1831	-17.87	11	0.48904	885.9
341	0.47426	1.1374	-12.09	-8.85	148	-15.18	2352	8.5822	737.4
342	0.66196	2.5235	-16.67	-10.38	2135	-25.21	638	10.297	999.9
343	0.41334	1.0278	-6.273	1.462	2300	-11.43	1000	5.4606	999.9
344	0.51857	0.91574	-1.793	3.781	139	-5.709	1830	3.1804	999.9
345	0.3383	0.41453	-5.701	-1.691	1515	-8.18	1150	3.7629	999.9
346	0.8554	3.5808	-3.217	1.104	1534	-8.44	325	8.5305	999.9
347	0.67937	3.5607	-7.58	-0.807	150	-13.84	1949	10.387	999.9
348	1.015	6.1406	-6.999	-1.652	1837	-6.999	410	10.268	999.9
349	0.66813	2.1456	-1.16	1.146	1545	-6.118	457	9.8963	999.9
350	0.71714	1.6357	-2.536	1.663	1514	-8.95	759	6.519	999.9
351	1.0086	6.1179	-0.152	2.17	259	-2.991	127	10.226	999.9
352	1.0387	6.8318	-8.53	-2.004	4	-15.98	2359	10.255	0
353	1.36	6.1428	-12.81	-3.317	1649	-19.26	821	9.6606	0
354	0.67874	3.5492	-9.53	-5.624	1554	-15.49	409	9.4894	0
355	0.3468	0.37388	-6.992	-2.502	1004	-12.12	2237	0.772	0
356	0.56302	1.7468	-17.09	-10.15	2334	-22.52	1109	4.7833	0
357	0.32797	0.34918	-16.48	-9.61	114	-25.23	2314	0.76949	0
358	0.12592	0.27454	-19.54	-16.08	1627	-24.34	639	0.6228	0
359	0.22881	1.5942	-11.47	-4.129	2235	-17.9	827	7.5021	0
360	1.1139	3.54	-6.841	-2.58	2310	-13.77	817	9.9463	0
361	1.1382	6.4144	-4.879	-1.673	1522	-17.88	2358	9.7182	0
362	0.44243	0.4261	-11.34	-1.628	2259	-19.99	256	0.79112	0
363	0.81661	4.3183	-16.3	-2.3	1.0	-25.4	2038.0	9.5	0
364	1.0896	5.2821	-23.9	-21.1	1421.0	-26.7	2005.0	9.0	0
0	0.50838	0.5435	-23.7	-22.9	2105.0	-24.8	1119.0	1.0	0
1	0.50556	0.91334	-22.3	-21.2	1613.0	-23.5	17.0	6.5	0
2	0.53613	1.6146	-26.19	-22.61	5	-29.19	2349	6.6978	0
3	0.47679	0.51952	-26.23	-19.57	2309	-29.91	1123	0.88663	0
4	1.2628	6.4864	-20.81	-12.04	0	-26.87	1102	10.656	0
5	0.9425	3.0978	-10.17	-6.409	2240	-14.63	1210	8.8694	0
Total	27.4	108.1							
Average	0.7	2.9	-12.1	-6.7		-17.8		6.8	344.0
Maximum	1.6	7.8	-0.2	3.8		-3.0		12.2	1000.0
Minimum	0.1	0.3	-26.2	-22.9		-29.9		0.5	0.0

TROUT LAKE - MONTHLY REPORT 2/SUMMARY OF ENVIRONMENTAL PARAMETERS NOV.1-30,1986

Day	G Solar kWh/m2	Ta Mean	Ta Max	Ta Max Time of	Ta Min	Ta Min Time of	G Solar MxInst	MxSolar Time of
304	16.565	-12.39	-08.61	1758	-19.21	939	4.7291	1334
305	22.17	-13.86	-08.04	1934	-21.27	837	3.5151	1200
306	12.154	-6.495	-3.485	1542	-08.19	1	1.8605	1156
307	32.566	-6999	28.18	1958	-6999	1944	4.5796	1301
308	24.586	-6999	191	1228	-6999	1217	5.8884	1401
309	7.7694	-08.28	-2.655	36	-12.9	2359	1.4612	1304
310	15.203	-16.19	-12.81	10	-18.76	2355	2.654	1317
311	40.206	-19.48	-15	1640	-26.16	939	4.9003	1350
312	28.115	-19.22	-17.13	645	-26.12	2141	4.7063	1327
313	37.423	-20.57	-14.79	1642	-26.74	2309	4.9601	1321
314	31.287	-23	-14.72	1642	-29.5	940	4.0039	1304
315	32.674	-21.56	-18.29	1644	-28.44	2238	4.2769	1225
316	17.728	-21.93	-15.13	2054	-28.99	106	3.3726	1357
317	26.808	-20.77	-17.44	1649	-25.73	1850	3.7195	1312
318	20.702	-21.54	-14.75	1551	-29.34	845	4.5181	1353
319	10.991	-18.99	-15.24	202	-22.42	829	2.0995	1354
320	11.233	-19.13	-17.4	530	-21.44	2300	2.3554	1516
321	29.131	-22.82	-20.98	1645	-28.88	2124	3.9736	1417
322	9.9829	-23.2	-18.51	1404	-30.31	408	1.7806	1406
323	6.4883	-23.94	-20.42	1505	-27	355	.96694	1346
324	7.1464	-23.67	-21.86	1809	-26.03	32	2.2959	1527
325	20.011	-26.11	-19.77	1529	-30.46	822	2.9598	1330
326	12.668	-27.01	-21.93	1650	-30.47	705	3.3287	1427
327	6.3931	-25.17	-22.96	0	-27.44	1240	1.7378	1605
328	3.4413	-22.15	-18.51	1509	-28.04	2334	.67452	1430
329	22.153	-6999	-5.806	2017	-6999	1038	22.78	2020
330	2.626	-19.1	-11.61	733	-28.05	2351	.38801	1406
331	3.6276	-23.94	-18.76	2357	-28.63	314	.87375	1507
332	16.922	-12.76	-3.608	2352	-19.12	746	3.4058	1413
333	14.36	-5.677	-2.109	1157	-11.76	2331	2.9458	1323

TROUT LAKE PV/HYBRID PVPGS
COMPLETE DAILY VALUES RECORDED Table 1
- OCT.16-31,1986

Day	Hour	BatVolt Maximum VB	Timeof VBmax	Ambient TempMx TAm	Timeof TAmax	Cell TempMx TCmax	Timeof TCmax	Battery TempMx TBm	timeof TBmax
290	0	30.71	1001	16.31	1453	38.93	1309	10.22	2
291	0	26.02	1454	4.713	536	3.147	548	7.53	4
292	0	26.38	1541	3.258	1729	7.11	1521	5.309	1724
293	0	30.8	1151	4.29	1507	27.21	1238	6.798	1827
294	0	26.82	1616	8.61	1615	31.95	1444	8.27	1900
295	0	26.14	1025	8.07	1557	23.99	1539	8.44	1906
296	0	26.4	1254	8.1	1455	25.47	1613	8.65	1858
297	0	26.66	1424	10.34	1431	28.98	1447	10.18	1730
298	0	25.26	325	2.144	148	7.44	1551	9.37	849
299	0	24.98	652	.219	1021	1.875	1440	7.22	1934
300	0	24.96	1430	-2.035	104	3.658	1431	5.689	1238
301	0	24.59	618	-4.092	55	-4.325	56	4.718	939
302	0	29.1	2014	-09.18	1438	13.3	1330	20.26	2011
303	0	29.68	1557	-07.16	1812	10.29	1406	13.12	911
304	0	29.27	1349	-4.984	1639	67.85	1241	95.5	1244

TROUT LAKE PV/HYBRID PVPGS
COMPLETE DAILY VALUES RECORDED Table 2
- OCT.16-31,1986

Day	RefTemp Max TPmax	Timeof TPmax	Battery MinVolt VB	Timeof VBmin	Ambient TempMn TAm	Timeof TAmin	Cell TemMin TCmin	Timeof TCmin	Battery TemMin TBm	Timeof TBmin
290	14.26	1506	25.82	837	-1.763	821	-4.302	823	6.124	954
291	5.3	1	25.22	1615	-0.273	2344	-0.883	406	4.765	2356
292	4.845	1822	25.13	1731	-1.399	2354	-2.956	2343	3.825	2350
293	3.684	1	24.88	2146	-4.118	853	-6.453	757	.832	1139
294	7.71	1755	24.38	1325	-1.069	355	-3.048	322	.764	1403
295	6.576	1736	24.37	1854	-2.495	829	-4.56	824	2.656	1017
296	7.28	1736	24.27	1815	-1.577	310	-3.29	134	1.664	1254
297	9.45	1510	24.18	1926	-1.648	829	-3.273	541	2.307	1234
298	7.2	1	23.76	1923	-2.164	717	-3.727	2047	4.154	2357
299	3.705	1203	23.01	1918	-4.096	524	-6.253	456	3.296	2354
300	2.288	1	22.9	1727	-4.875	2058	-5.172	2059	1.766	1428
301	1.175	1	22.25	2020	-11.31	0	-11.52	2359	.401	2359
302	6999	2007	-6999	1941	-6999	1939	-6999	2007	-6999	2007
303	-1.979	1332	-6999	1550	-6999	1550	-25.3	210	-23.87	1555
304	31.19	1242	-6999	1220	-6999	1211	-6999	1242	-6999	1242

TROUT LAKE PV/HYBRID RESIDENTIAL PGS----------

MONTHLY ARRAY EFFICIENCY REPORT

Array Area = 7.6m2 MONTH OF JAN.1987

Day	Ta Ambient	Global Wh/m2	Total Wh/m2	Ratio Tot/Glo	EA inWh/m2	EA/IT %	Total incidnt Wh	EA Wh	Vb battery Volts
6	0.101	308	1301	4.1775	95	7.354	9913	729	24.99
7	-6.322	237	642	2.6733	46	7.1958	4905	352	24.87
8	0.828	265	798	2.9746	58	7.239	6091	440	25.02
9	-4.584	499	2608	5.1937	204	7.8191	19838	1551	25.06
10	-10.35	184	273	1.4773	14	5.1286	2113	108	24.89
11	-26.69	180	276	1.5501	1	0.42372	2148	9	24.82
12	-21.9	496	2224	4.4484	159	7.1515	16931	1210	25.01
13	-12.85	625	2754	4.3806	217	7.8759	20967	1651	25.1
14	-11.74	364	1695	4.5894	122	7.2386	12911	934	25.09
15	-6.409	178	193	1.0841	7	3.6749	1497	55	24.93
16	-13.18	188	177	0.95153	4	2.2926	1381	31	24.88
17	-7.3	437	1369	3.118	97	7.0616	10439	737	25.03
18	-2.36	205	223	1.0903	10	4.411	1736	76	24.84
19	-10.69	279	837	2.9506	57	6.8059	6378	434	24.93
20	-18.1	620	3198	5.1288	265	8.2848	24327	2015	25.16
21	-18.42	590	3204	5.3917	262	8.1699	24381	1991	25.23
22	-16.58	602	3214	5.3041	262	8.1548	24453	1994	25.3
23	-14.73	420	1330	3.1573	101	7.583	10137	768	25.24
24	-15.3	330	516	1.5552	32	6.3144	3962	250	25.1
25	-13.06	299	318	1.0716	12	3.7618	2462	92	25.06
26	-17.17	544	746	1.37	55	7.4247	5713	424	24.88
27	-24.43	219	176	0.81366	1	1.0581	1381	14	19.74
28	-61.82	520	1161	2.2318	17533	1500.7	8878	99999	-6999
29	-29.13	328	379	1.1613	-902	-233.26	2939	-6855	24.71
30	-22.79	276	1557	5.555	110	7.0789	11867	840	24.2
Average	-15.4	367.7	1246.8	2.9	752.9	56.3	9509.9	4394.0	-256.2
Maximum	0.8	625.0	3214.0	5.6	17533.0	1500.7	24453.0	99999.0	25.3
Minimum	-61.8	178.0	176.0	0.8	-902.0	-233.3	1381.0	-6855.0	-6999.0

Corrected Values omitting Days 28 and 29

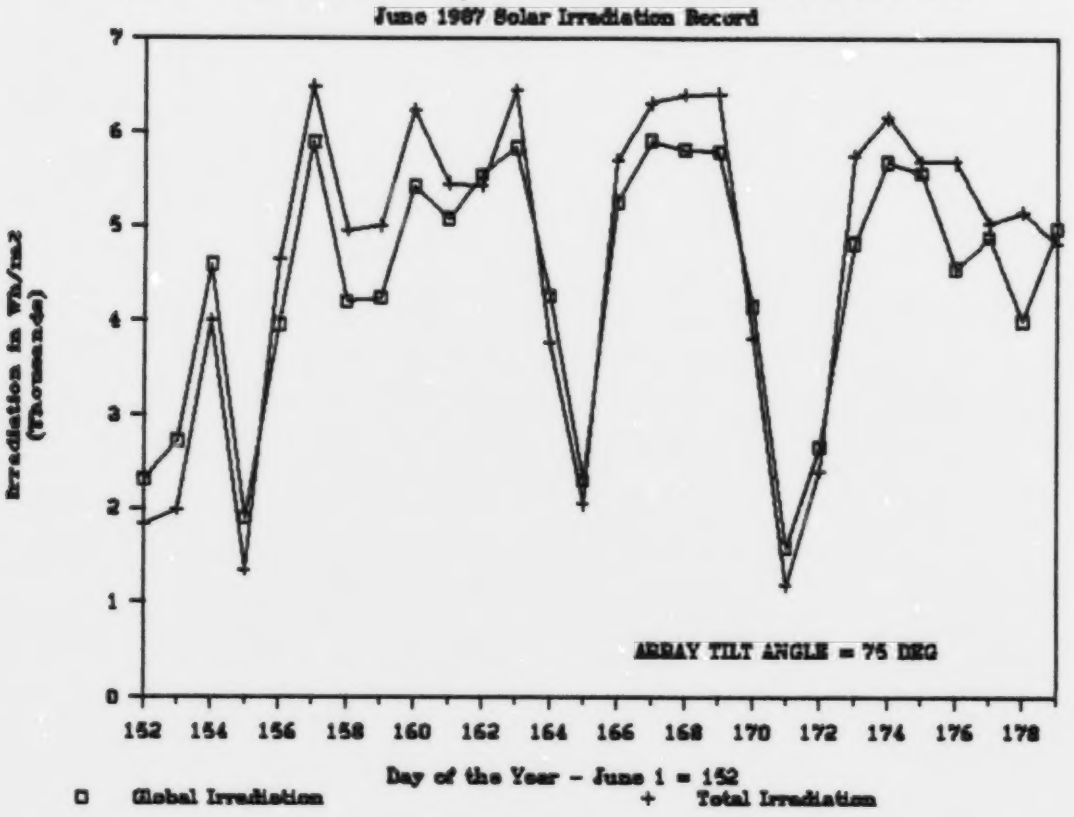
Average	-12.78	362.83	1288.22	3.04	95.26	6.07	9823.09	726.30	24.76
Maximum	0.83	625.00	3214.00	5.56	265.00	8.28	24453.00	2015.00	25.30
Minimum	-26.69	178.00	176.00	0.81	1.00	0.42	1381.00	9.00	19.74

mer-jan

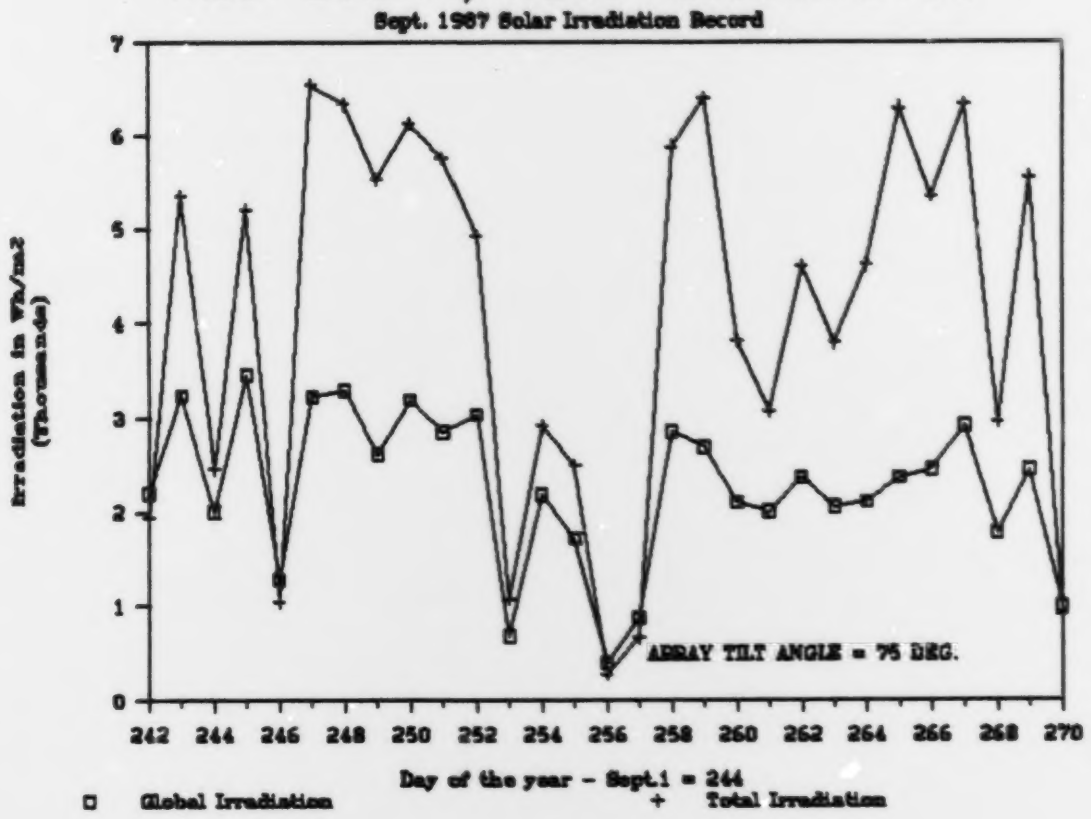
MONTHLY SUMMARY "MRS" FOR NOVEMBER 1986
Trial Run for Daily Values from Hourly

Day	BatVolt Volts	Ambient Deg C	Global Whm2	Total Wh/m2	EG Wh	EII Wh	EIO Wh	EA Wh	ECI Wh
305	24.41	-8.18	720	1665	2391	26	2584	986	1557
306	24.22	-5.947	395	368	3609	101	2841	76	2039
307	24.74	3.456	1045	3525	11452	9412	16351	16126	-36
308	24.73	-4.791	834	1910	12845	165	16345	14858	15771
309	24.56	-12.86	239	213	2266	26	1900	7	1631
310	24.42	-18.75	497	586	0	0	-16	47	-3
311	24.87	-17.62	1311	4259	0	0	-24	2470	-24
312	24.93	-20.82	939	2996	0	0	-24	1708	-24
313	25.1	-22.53	1231	4143	0	0	-15	2671	-24
314	25.21	-19.18	1018	3929	0	0	0	2479	-11
315	25.29	-26.96	1055	3773	0	0	0	2182	0
316	25.13	-19.13	584	998	0	0	0	565	0
317	25.39	-19.68	871	3323	0	0	0	2040	0
318	25.32	-15.77	669	1584	0	0	0	1061	0
319	25.15	-17.49	372	430	0	0	0	100	0
320	25.09	-21.15	365	581	0	0	0	201	0
321	25.46	-24.32	948	3486	3	0	0	1883	0
322	25.17	-24.29	317	437	1651	9	1162	173	1312
323	24.81	-25.81	207	261	5454	59	6073	61	3981
324	24.82	-22.9	227	409	8736	54	5980	107	6411
325	24.24	-29.44	640	2922	733	182	6485	1530	-74
326	24.49	-26.28	405	1099	2443	62	2395	544	1667
327	24.5	-22.96	196	203	976	3	449	37	746
328	24	-27.29	106	1362	12929	7086	5830	660	4026
329	23.97	-15.67	1013	526	37332	28076	31087	28072	2741
330	24.51	-27.5	80	256	9811	56	4722	88	7462
331	24.11	-18.79	114	2058	5258	156	4907	1209	3316
332	24.47	-3.969	565	2427	3475	20	1073	1363	954
333	24.59	-10.34	456	2197	4648	0	-24	1287	-24
TOTAL			17419.0	51926.0	126012.0	45493.0	110081.0	84591.0	53394.0
Average	24.7	-18.2	600.7	1790.6	4345.2	1568.7	3795.9	2916.9	1841.2
Maximum	25.5	3.5	1311.0	4259.0	37332.0	28076.0	31087.0	28072.0	15771.0
Minimum	24.0	-29.4	80.0	203.0	0.0	0.0	-24.0	7.0	-74.0

TROUT LAKE PV/HYBRID RESIDENTIAL PGS



TROUT LAKE PV/HYBRID RESIDENTIAL PGS



APPENDIX C

Photographs

TROUT LAKE NWT
1986 OCTOBER

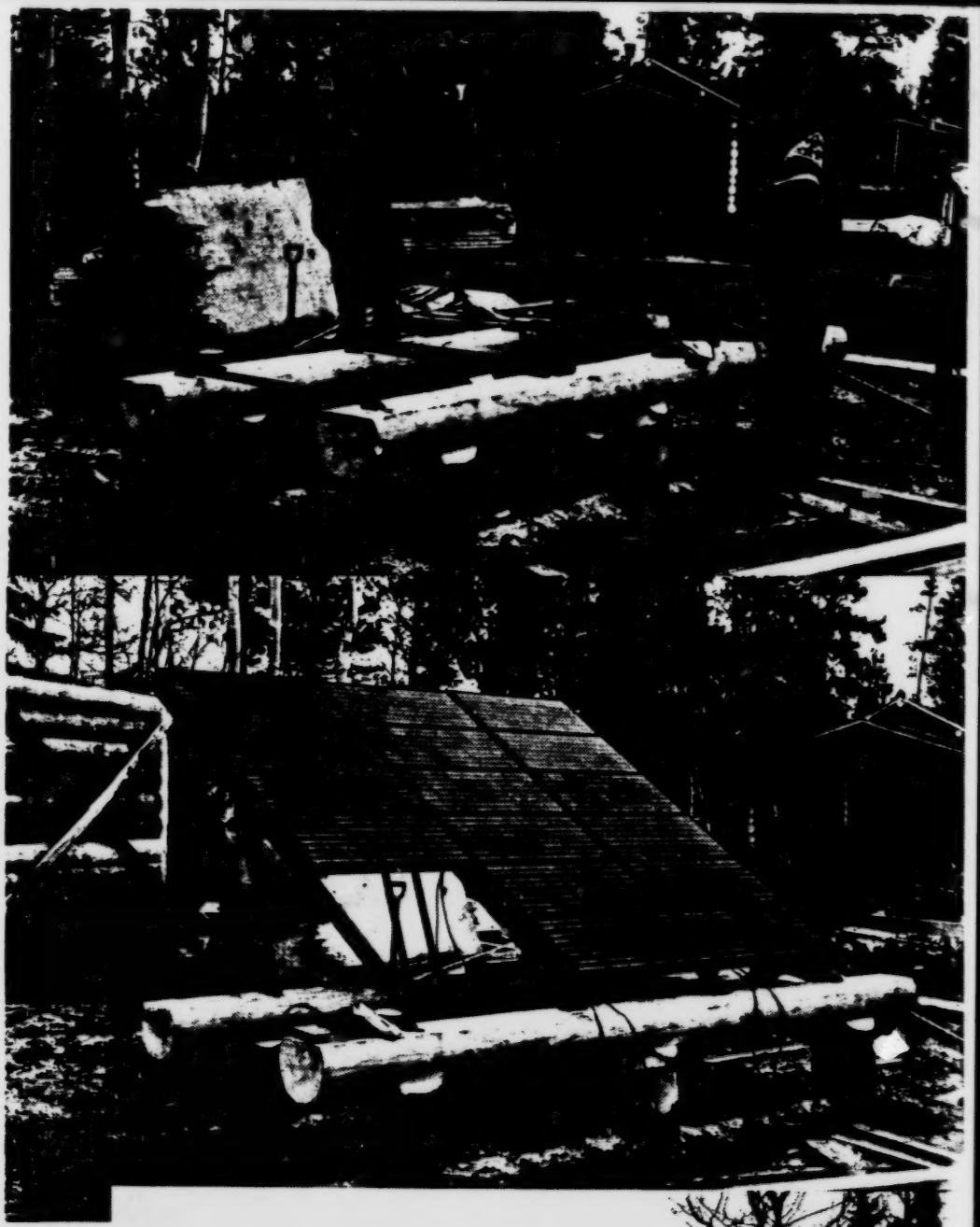
AERIAL VIEW

EXTERIOR STATUS

INSTALLING BATTERIES

TROUT LAKE NWT
1986 OCTOBER

ERECTING THE SOLAR
ARRAY



ARRAY IN SUMMER
POSITION 34 DEG

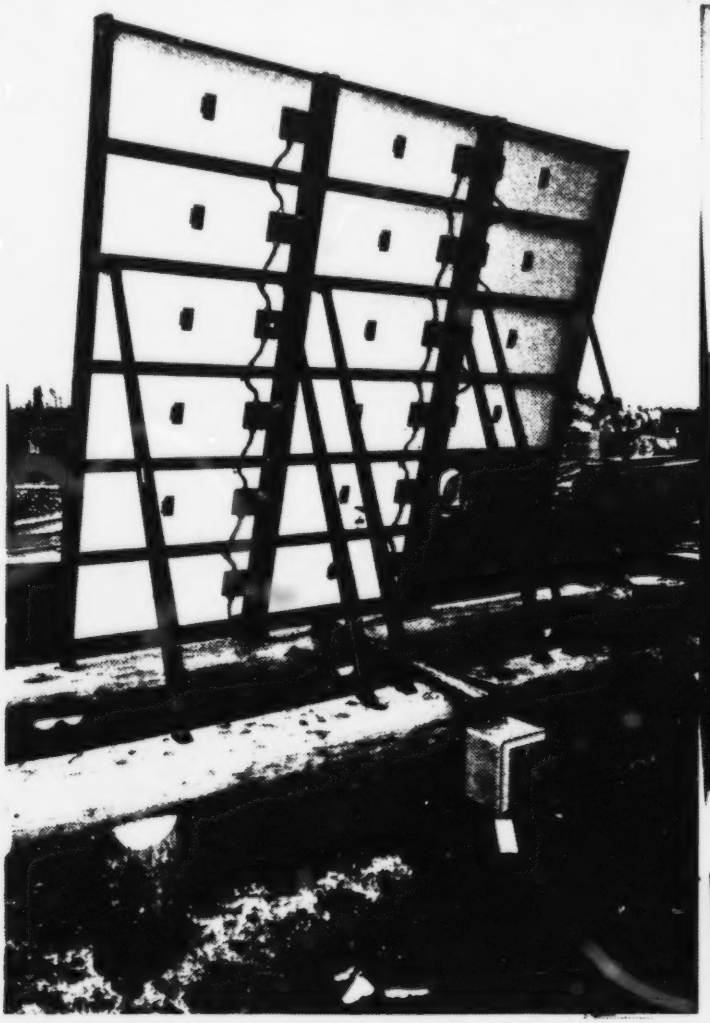
ARRAY IN WINTER
POSITION 75 DEG

TROUT LAKE NWT
1986 OCTOBER

COMPLETED ARRAY
WITH "TOTAL"
PYRANOMETER

GENERATOR SHED TO
RIGHT TAKING SHAPE

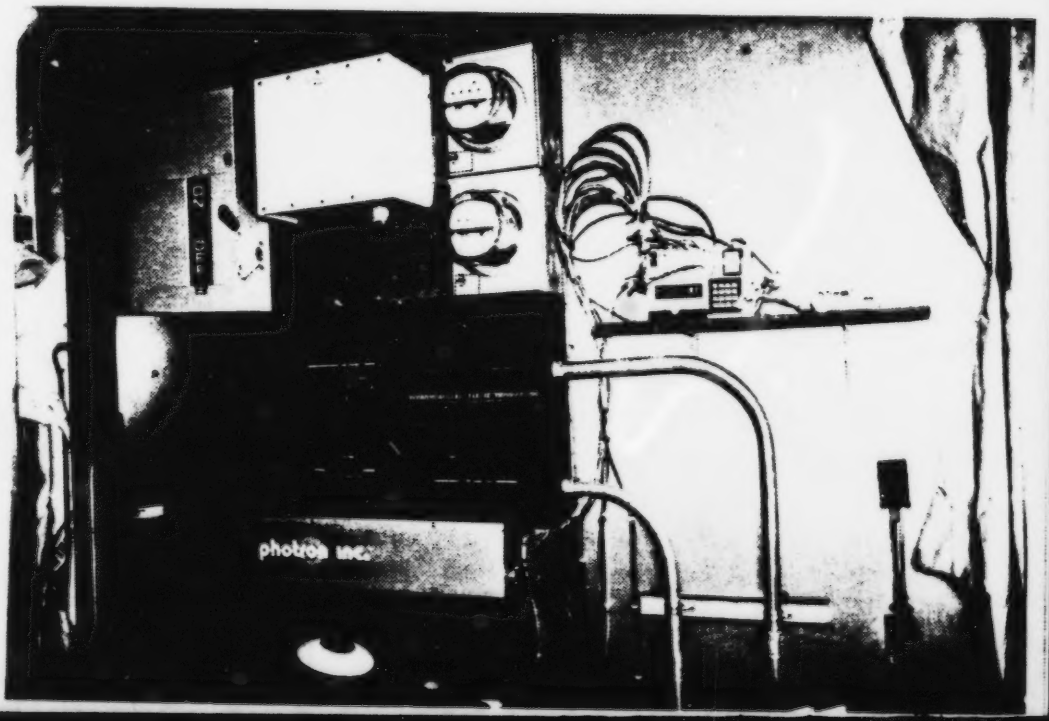
HONDA GENERATOR
IN THE SHED



REAR OF ARRAY

CONTROL ROOM WITH
BATTERIES

TROUT LAKE NWT
1986 OCTOBER



CONTROL BOARD
OVERALL VIEW

TROUT LAKE NWT
1987 OCTOBER

"GLOBAL" PYRANOMETER
LOCATION

"CELL" - SENSOR
AND "TOTAL"
PYRANOMETER

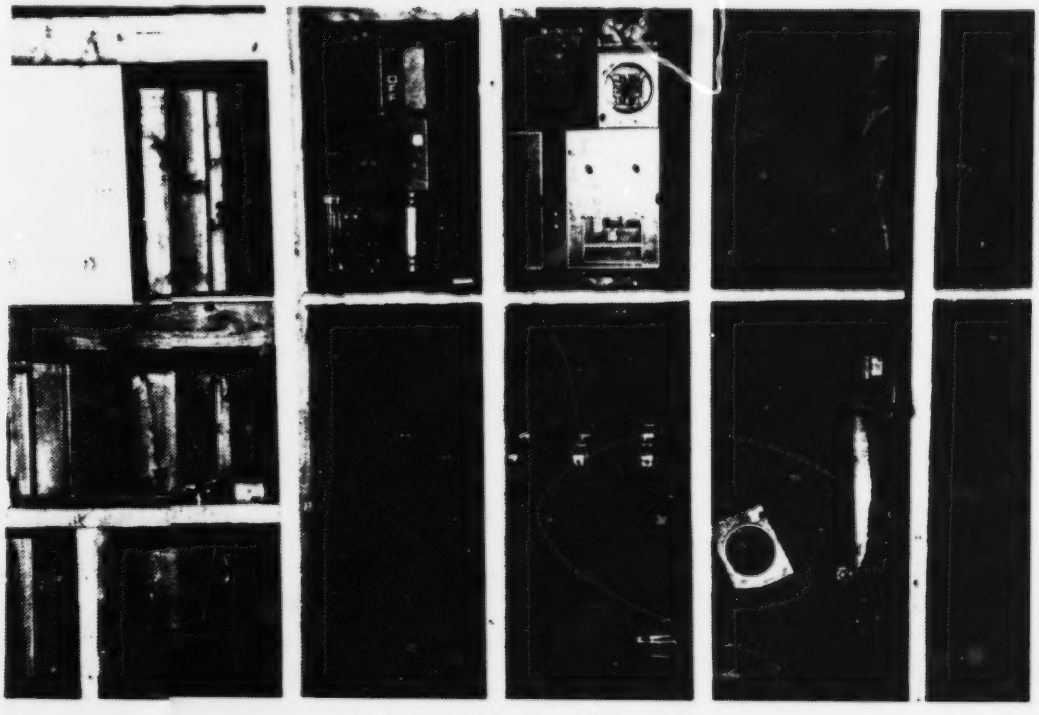
AMBIENT TEMPERATURE
SENSOR

TROUT LAKE NWT
1987 OCTOBER

CONTROL BOARD
OVERALL VIEW

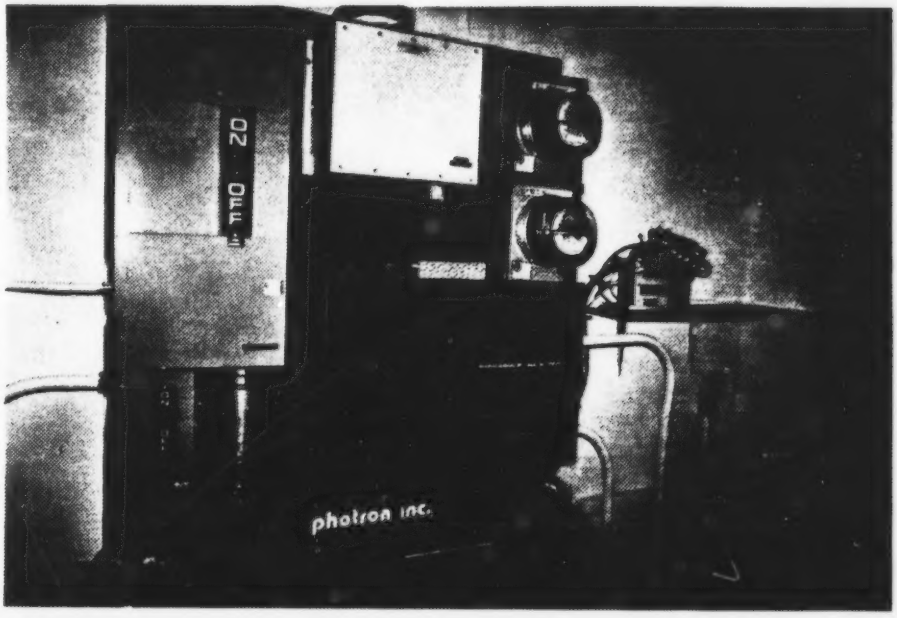
TROUT LAKE NWT
1986 OCTOBER

CONTROL ROOM DURING
CONSTRUCTION

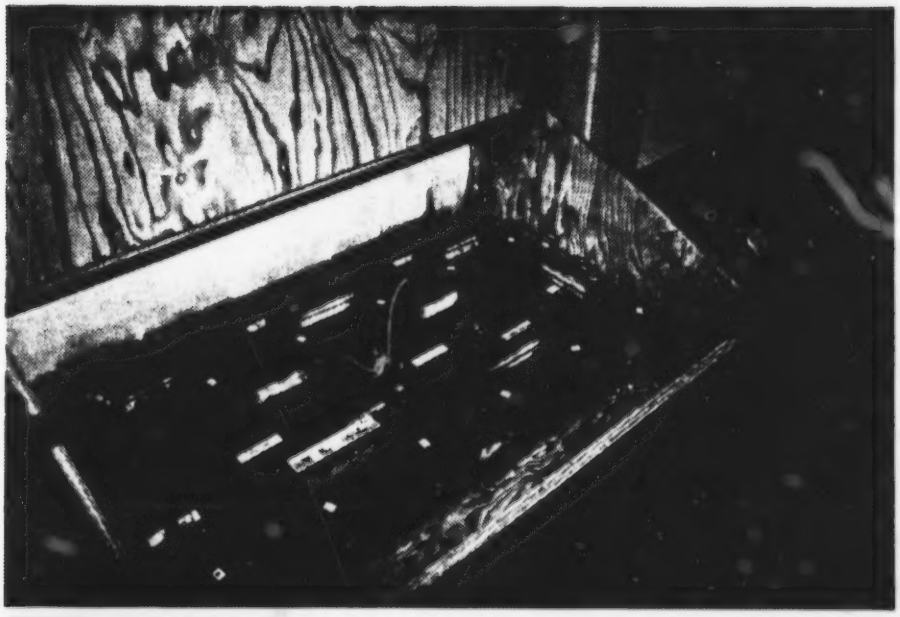


TROUT LAKE NWT
1987 OCTOBER

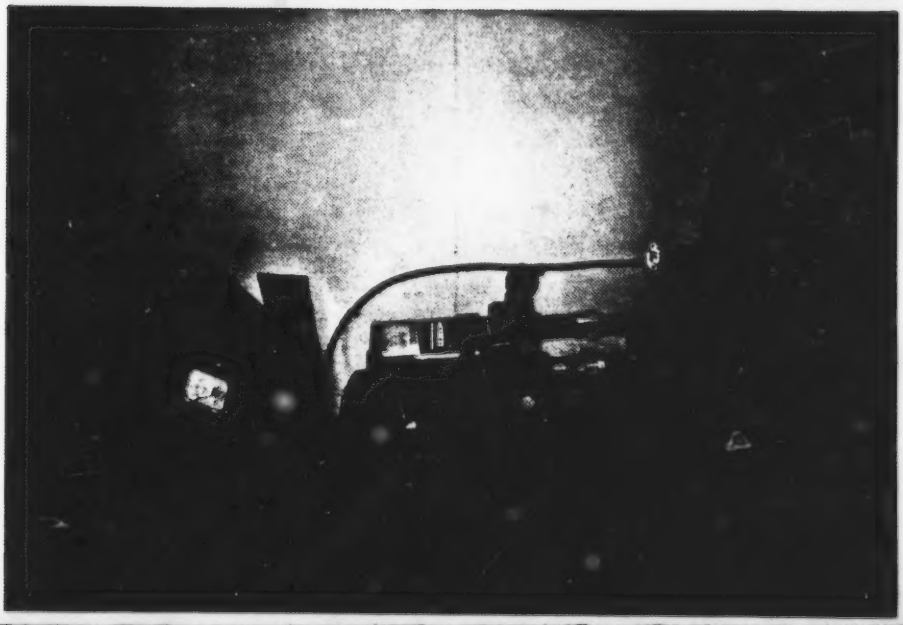
DATALOGGER SHOWN
ON SHELF AT RIGHT



BATTERY ENCLOSURE
CHARGER TO RIGHT



BATTERY CHARGER
AND WATER PUMP



APPENDIX D

Monitor Data Records

THIS IS A SAMPLE OF THE RAW DATA RECEIVED FROM THE SITE

ON CASSETTE TAPE : This data is from the start of the June,1987 tape

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TROUT LAKE PV/HYBRID PVPGS
COMPLETE HOURLY VALUES RECORDED - May.1-31,1987

Day	Hour	MaxInv Output	Time of G	Solar T IG	Solar IA	BatVolt Vb	Ambient TempTA	Cell TempTC	Battery TempTB
119	600	3.6	505	251.9	201.7	28.77	15.89	19.54	13.59
119	700	0	601	110	87.9	28.43	14.44	17.21	13.7
119	800	0	701	71.8	60.54	28.08	13.1	13.16	13.72
119	900	0	801	27.37	27.69	27.72	7.99	6.492	13.77
119	1000	0	901	9.72	7.21	27.37	11.92	10.74	13.79
119	1100	0	1001	.082	0	27.11	10.73	9.83	13.77
119	1200	0	1101	0	0	26.91	10.76	10.13	13.71
119	1300	0	1201	0	0	26.74	10.34	9.76	13.67
119	1400	0	1301	0	.08	26.6	4.994	5.491	13.64
119	1500	0	1401	0	.037	26.47	5.564	4.947	13.56
119	1600	0	1501	0	0	26.35	4.22	3.001	13.49
119	1700	0	1601	0	0	26.23	3.711	2.732	13.41
119	1800	0	1701	0	.002	26.13	2.236	.581	13.34
119	1900	0	1801	13.27	9.55	26.16	2.151	2.874	13.21
119	2000	0	1901	49.52	32.42	26.4	2.778	5.318	13.03
119	2100	0	2001	83.4	58.83	26.89	3.158	6.533	12.92
119	2200	0	2101	93.9	63.06	27.33	4.773	7.64	12.85
119	2300	0	2201	150.1	111.5	28	5.506	9.17	12.8
120	0	0	2301	241	188.8	29.38	6.248	11.94	12.36
120	100	0	1	350.9	311.7	30.18	7.7	16.92	12.13
120	200	0	101	460.4	463.6	29.99	15.74	21.91	12.5
120	300	0	201	216.6	158.9	29.31	17.12	20.25	12.58
120	400	0	301	315.4	267.9	30.67	19.17	23.78	11.53
120	500	0	401	335.4	268.8	29.1	19.33	21.61	12.91
120	600	0	501	164.1	106.7	28.4	18.64	19.61	13.24
120	700	0	601	39.19	25.51	27.81	14.41	13.03	13.4
120	800	0	701	22.22	13.25	27.55	12.81	11.75	13.4
120	900	0	801	14.96	8.1	27.33	11.99	11.12	13.45
120	1000	0	901	3.94	1.716	27.12	11.74	10.72	13.44
120	1100	0	1001	.54	.123	26.93	11.57	10.66	13.43
120	1200	0	1101	.264	0	26.77	11.3	10.44	13.36
120	1300	0	1201	0	0	26.62	10.87	10.17	13.32
120	1400	0	1301	0	0	26.48	9.31	8.15	13.27
120	1500	0	1401	0	0	26.36	8.07	7.52	13.24
120	1600	0	1501	0	0	26.25	7.01	5.167	13.2
120	1700	0	1601	0	0	26.15	5.842	3.89	13.14
120	1800	0	1701	.018	.066	26.06	5.081	3.091	13.12
120	1900	0	1801	18.56	13.56	26.16	5.202	3.814	12.97
120	2000	0	1901	97.5	79.5	26.92	6.856	7.95	12.56
120	2100	0	2001	164.8	310	30.13	8.57	14.28	11.82
120	2200	0	2101	275.6	524.1	30.97	9.09	17.34	11.55
120	2300	0	2201	472.5	697.1	31.34	10.42	20.84	11.36
121	0	0	2301	513.1	710	31.14	11.21	22.38	12.13
121	100	0	1	608.9	770	31.49	12.63	25.59	11.77
121	200	0	101	718	919	31.44	14.01	29.03	12.33
121	300	0	201	715	891	31.06	12.41	27.9	13.41
121	400	0	301	648.3	698.8	31.03	12.46	26.36	13.71
121	500	0	401	579.9	556.5	30.32	11.17	20.73	14.48
121	600	0	501	359.8	316.8	29.56	11.25	17.34	14.59
121	700	0	601	125.5	153.9	28.89	12.77	15.71	15.02

TROUT LAKE PV/HYBRID PVPGS
COMPLETE HOURLY VALUES RECORDED - May.1-31,1987

Day	Hour	MaxInv Output	Time of G	Solar IG	T Solar IA	BatVolt Vb	Ambient TempTA	Cell TempTC	Battery TempTB
121	800	0	701	87	66.79	28.03	12.42	11.76	15.31
121	900	0	801	55.84	37.25	27.73	10.47	10.33	15.32
121	1000	0	901	20.3	13.32	27.39	10.76	8.92	15.38
121	1100	0	1001	.402	.431	27.11	9.38	8.39	15.37
121	1200	0	1101	0	0	26.9	8.79	7.96	15.28
121	1300	0	1201	0	0	26.73	7.48	6.597	15.22
121	1400	0	1301	0	0	26.57	6.109	5.34	15.16
121	1500	0	1401	0	0	26.44	7.28	6.354	15.09
121	1600	0	1501	0	0	26.32	5.931	4.391	15
121	1700	0	1601	0	0	26.2	4.873	3.055	14.93
121	1800	0	1701	.008	.13	26.11	2.402	.696	14.83
121	1900	0	1801	16.27	12.68	26.17	4.306	3.397	14.71
121	2000	0	1901	97.9	76.2	26.91	3.59	6.569	14.23
121	2100	0	2001	160.6	304.7	29.81	8.72	15.97	13.6
121	2200	0	2101	261.8	516.5	30.83	10.93	21.62	13.28
121	2300	0	2201	461.6	692.5	31.16	9.87	24.03	13.1
122	0	0	2301	599.9	840	31.3	9.51	27.42	13.23
122	100	0	1	608.7	784	30.88	11.6	23.56	14.05
122	200	0	101	545.8	646.3	29.98	11.89	20.95	15.3
122	300	0	201	739	821	31.16	13.24	28.2	14.35
122	400	0	301	659.9	701	30.8	13.98	21.1	14.54
122	500	0	401	580.2	506.1	30.39	15.46	22.65	14.99
122	600	0	501	370.3	290.8	28.96	14.31	17.29	16.12
122	700	0	601	155.4	143.9	28.73	15.31	17.03	16.26
122	800	0	701	118.8	80.8	28.2	10.42	12.28	16.43
122	900	0	801	39.01	35.29	27.69	9.95	9.23	16.47
122	1000	0	901	22.18	14.9	27.35	7.38	6.479	16.52
122	1100	0	1001	0	0	27.06	6.251	1.188	16.48
122	1200	0	1101	0	0	26.86	3.079	-1.269	16.4
122	1300	0	1201	0	0	26.69	2.13	-2.347	16.33
122	1400	0	1301	.533	.907	26.54	5.406	3.177	16.23
122	1500	0	1401	.415	.248	26.41	3.584	2.14	16.14
122	1600	0	1501	0	0	26.28	5.419	4.648	16.04
122	1700	0	1601	0	0	26.16	5.779	4.581	15.97
122	1800	0	1701	.496	.31	26.07	5.589	5.144	15.87
122	1900	0	1801	11.24	7.77	26.07	5.588	5.331	15.73
122	2000	0	1901	54.2	35.32	26.32	7.03	7.55	15.57
122	2100	0	2001	69.2	51.85	26.76	7.08	8	15.32
122	2200	0	2101	190.2	266.1	30.19	9.58	17.83	13.7
122	2300	0	2201	468.9	691.5	31.05	8.39	22.22	13.75
123	0	0	2301	600.7	837	31.27	8.14	28.82	13.77
123	100	0	1	684.5	929	31.3	9.57	29.2	14.1
123	200	0	101	470.7	600.9	31.24	8.52	26.5	13.75
123	300	0	201	490.6	539.8	31.07	10.13	25.57	14.1
123	400	0	301	655.3	636.7	30.92	10.85	24.87	15.23
123	500	3.6	436	427.6	368.3	29.38	7.38	17.16	16.25
123	600	0	501	256.7	203.9	29.55	9.02	17.85	16.23
123	700	0	601	115.2	118.8	28.65	8.81	12.23	16.65
123	800	0	701	80.9	71.5	28	8.72	8.39	16.8
123	900	0	801	30.31	28.96	27.6	7.23	6.05	16.81

TROUT LAKE PV/HYBRID PVPGS
COMPLETE HOURLY VALUES RECORDED - May.1-31,1987

Day	Hour	MaxInv Output	Time of G	Solar T IG	Solar IA	BatVolt Vb	Ambient TempTA	Cell TempTC	Battery TempTB
123	1000	0	901	10.77	10.61	27.3	6.938	5.229	16.79
123	1100	0	1001	.357	.63	27.03	7.15	5.44	16.71
123	1200	0	1101	0	0	26.82	6.759	5.392	16.63
123	1300	0	1201	0	0	26.66	6.384	4.93	16.55
123	1400	0	1301	0	0	26.5	5.371	3.726	16.41
123	1500	0	1401	0	0	26.37	4.629	3.205	16.3
123	1600	0	1501	0	0	26.25	4.25	2.722	16.2
123	1700	0	1601	0	0	26.14	4.001	2.575	16.09
123	1800	0	1701	1.019	1.02	26.06	4.101	3.019	15.96
123	1900	0	1801	24.38	22.13	26.22	4.528	4.34	15.73
123	2000	0	1901	140.6	106.9	27.25	7.25	9.71	15.15
123	2100	0	2001	186	213.6	28.9	7.47	10.41	14.9
123	2200	0	2101	244.4	339.2	29.87	8.52	12.59	14.47
123	2300	0	2201	387.4	526.5	30.96	9.62	20.44	13.83
124	0	0	2301	602.2	833	31.24	11.78	25.63	13.77
124	100	0	1	694.2	926	31.28	11.7	26.18	14.04
124	200	0	101	736	935	31.19	10.64	30.73	14.61
124	300	0	201	707	821	29.82	9.77	27.66	16.58
124	400	0	301	482.3	521.9	30.65	8.64	18.16	14.62
124	500	0	401	582.2	494.7	30.32	11.86	20.75	15.62
124	600	0	501	405.3	309.4	28.85	8.89	14.42	16.9
124	700	0	601	106.8	108.7	28.37	8.89	10.35	17.05
124	800	0	701	57.1	55.77	28	8.4	7.86	17.06
124	900	0	801	42.24	38.68	27.61	6.373	4.85	17.11
124	1000	0	901	10.19	10.96	27.3	5.831	3.312	17.08
124	1100	0	1001	.31	.716	27.03	4.026	-.158	17.01
124	1200	0	1101	0	0	26.82	5.557	3.878	16.91
124	1300	0	1201	0	0	26.65	5.633	3.817	16.82
124	1400	0	1301	0	0	26.5	5.034	3.301	16.7
124	1500	0	1401	0	0	26.36	4.296	2.596	16.58
124	1600	0	1501	0	0	26.24	3.916	2.249	16.46
124	1700	0	1601	0	0	26.13	3.518	1.936	16.36
124	1800	0	1701	.654	.924	26.05	3.312	2.005	16.19
124	1900	0	1801	24.54	17.71	26.17	-.004	.359	16.02
124	2000	0	1901	116.7	81.7	26.94	4.497	6.857	15.54
124	2100	0	2001	178.1	314.9	29.77	6.973	17.43	14.75
124	2200	0	2101	242.3	528.1	30.74	11	23.89	13.94
124	2300	0	2201	437.2	676.3	31.02	10.58	32.24	14.24
125	0	0	2301	600.6	849	31.18	9.14	31.35	14.29
125	100	0	1	678	917	31.21	12.61	32.54	14.61
125	200	0	101	681.4	888	31.03	13.39	40.05	15.11
125	300	0	201	669	828	30.93	13.88	35.01	15.39
125	400	0	301	600.7	651.7	30.47	14.65	28.93	15.74
125	500	0	401	498.5	455.4	30.12	13.38	25.89	16.2
125	600	0	501	406.7	313.5	29.22	16.23	20.9	17.15
125	700	0	601	141.4	132	28.72	15.48	18.3	17.35
125	800	0	701	119.9	86.9	28.26	15.75	16.8	17.49
125	900	0	801	60.48	44.59	27.66	14.19	13.45	17.58
125	1000	0	901	17.47	11.25	27.29	13.1	11.82	17.57
125	1100	0	1001	.196	.106	27	11.99	10.39	17.51

TROUT LAKE PV/HYBRID PVPGS
COMPLETE HOURLY VALUES RECORDED - May.1-31,1987

Day	Hour	MaxInv Output	Time of G	Solar T IG	Solar IA	BatVolt Vb	Ambient TempTA	Cell TempTC	Battery TempTB
125	1200	0	1101	0	0	26.79	10.66	8.56	17.44
125	1300	0	1201	0	0	26.61	9.19	7.4	17.35
125	1400	0	1301	0	0	26.46	8.53	6.412	17.28
125	1500	0	1401	0	0	26.33	7.54	5.597	17.17
125	1600	0	1501	.77	.214	26.2	8.72	6.895	17.08
125	1700	0	1601	0	0	26.09	6.24	3.585	16.99
125	1800	0	1701	.011	.086	26	5.693	2.124	16.88
125	1900	0	1801	11.28	9.94	26.02	6.276	5.883	16.73
125	2000	0	1901	117.7	76.8	26.78	7.14	11.61	16.27
125	2100	0	2001	152.5	193.4	28.44	9.13	11.82	15.48
125	2200	0	2101	274.6	519.8	30.82	10.62	20.92	14.57
125	2300	0	2201	406.8	527.3	29.85	9.25	12.75	15.49
126	0	0	2301	509.2	598.4	31.22	9.76	23.7	14.64
126	100	0	1	707	932	31.25	10.46	25.44	14.97
126	200	0	101	751	951	31.16	10.26	29.17	15.49
126	300	0	201	754	880	31	10.59	27.48	15.98
126	400	0	301	720	744	30.71	9.79	23.13	16.01
126	500	0	401	644.6	550.4	30.12	10.56	19.69	16.67
126	600	0	501	452.3	314.2	29.15	9.24	13.97	17.71
126	700	0	601	52.25	97.7	28.2	9.28	10.06	18.07
126	800	0	701	45.77	52.87	27.78	9.23	7.71	18.1
126	900	0	801	31.64	30.09	27.5	7.2	6.035	18.04
126	1000	0	901	14.87	14.16	27.26	5.545	3.231	18
126	1100	0	1001	.537	.404	26.99	4.151	1.918	17.94
126	1200	0	1101	0	0	26.77	3.189	1.916	17.84
126	1300	0	1201	.146	0	26.6	2.681	.838	17.73
126	1400	0	1301	.065	0	26.45	2.503	2.073	17.59
126	1500	0	1401	.074	0	26.32	.954	-1.813	17.51
126	1600	0	1501	0	0	26.2	.049	-2.567	17.37
126	1700	0	1601	0	0	26.09	.163	-1.793	17.26
126	1800	0	1701	1.296	.67	26.01	-.227	-1.387	17.1
126	1900	0	1801	19.12	12.87	26.06	1.116	.874	16.88
126	2000	0	1901	67.34	45.82	26.4	1.681	3.728	16.71
126	2100	0	2001	123.8	92.6	27.23	2.052	7.67	16.4
126	2200	0	2101	194.3	345.3	30.43	2.956	22.8	14.82
126	2300	0	2201	461.5	693.2	31	4.47	28.26	14.77
127	0	0	2301	611.5	861	31.13	5.836	33.34	14.94
127	100	0	1	688.9	935	31.17	6.56	33.89	15.28
127	200	0	101	743	974	31.18	7.74	31.48	15.61
127	300	0	201	605.6	752	30.71	8.21	24.17	15.84
127	400	0	301	690.5	742	30.75	9.21	29.35	16.11
127	500	0	401	596.4	526	30.51	9.36	27.5	16.59
127	600	0	501	312.4	267.4	29.43	8.96	16.41	17.72
127	700	0	601	93.5	125.6	28.37	7.59	9.77	18.16
127	800	0	701	94.8	74	28.07	5.73	7.25	18.18
127	900	0	801	42.33	38.66	27.58	7.02	6.527	18.23
127	1000	0	901	11.38	10.35	27.24	5.435	4.904	18.19
127	1100	0	1001	.087	.511	26.97	3.514	1.949	18.07
127	1200	0	1101	0	0	26.76	2.627	-.477	17.96
127	1300	0	1201	0	0	26.59	2.471	-.479	17.85

TROUT LAKE PV/HYBRID PVPGS
COMPLETE HOURLY VALUES RECORDED Table 2
- May.1-31,1987

Day	Hour	Refrnce TempTP	Gen Hr Output EG	Inv.Hr Output EIO	Inv.Hr Input EII	ArrayHr Output EA	BatChgr Output ECH	Bat.Net Energy EB	Total AC Load ELA	Engy to BatChgr EC	GenLoad Direct EGD
119	600	10.55	0	18	-6999	-40.99	82.3	153.2	-88.9	106.9	-106.9
119	700	10.54	0	0	-6999	-26.8	26.55	119.2	-34.48	34.48	-34.48
119	800	10.56	0	0	-6999	-21.28	17.92	98.7	-23.28	23.28	-23.28
119	900	10.59	0	0	-6999	-15.18	7.89	76.8	-10.25	10.25	-10.25
119	1000	10.63	0	0	-6999	-11.55	1.453	60.73	-1.887	1.887	-1.887
119	1100	10.71	0	0	-6999	-9.75	-1.735	53.27	2.253	-2.253	2.253
119	1200	10.77	0	0	-6999	-9.67	-1.494	52.14	1.94	-1.94	1.94
119	1300	10.85	0	0	-6999	-9.55	-1.566	51.8	2.034	-2.034	2.034
119	1400	10.9	0	0	-6999	-9.29	-1.416	51.5	1.839	-1.839	1.839
119	1500	10.93	0	0	-6999	-9.22	-1.245	51.25	1.617	-1.617	1.617
119	1600	10.92	0	0	-6999	-9.15	-1.756	51.05	2.28	-2.28	2.28
119	1700	10.91	0	0	-6999	-9.18	-1.66	50.76	2.155	-2.155	2.155
119	1800	10.89	0	0	-6999	-9.16	-1.675	51.26	2.175	-2.175	2.175
119	1900	10.86	0	0	-6999	-10.95	1.817	57.33	-2.36	2.36	-2.36
119	2000	10.82	0	0	-6999	-15.22	8.17	71.4	-10.62	10.62	-10.62
119	2100	10.79	0	0	-6999	-19.99	16.17	89.6	-21	21	-21
119	2200	10.75	0	0	-6999	-21.56	17.71	95.1	-23.01	23.01	-23.01
119	2300	10.7	0	0	-6999	-30.43	32.57	130.6	-42.3	42.3	-42.3
120	0	10.69	0	0	-6999	-45.65	58.59	190.7	-76.1	76.1	-76.1
120	100	10.71	0	0	-6999	-67.21	99.9	283.4	-129.7	129.7	-129.7
120	200	10.75	0	0	-6999	-92.1	152	396.7	-197.5	197.5	-197.5
120	300	10.91	0	0	-6999	-41.91	50.16	174.2	-65.14	65.14	-65.14
120	400	11.21	0	0	-6999	-59.75	84.3	251.2	-109.5	109.5	-109.5
120	500	11.73	0	0	-6999	-62.16	87.4	254.6	-113.5	113.5	-113.5
120	600	12.17	0	0	-6999	-32.35	33	134.7	-42.86	42.86	-42.86
120	700	12.15	0	0	-6999	-15.2	7.04	74.9	-9.15	9.15	-9.15
120	800	12.07	0	0	-6999	-12.81	3.092	66.6	-4.015	4.015	-4.015
120	900	12.12	0	0	-3999	-11.58	1.711	61.63	-2.222	2.222	-2.222
120	1000	12.11	0	0	-6999	-10.02	-.594	55.53	.771	-.771	.771
120	1100	12.08	0	0	-6999	-9.43	-1.766	53.03	2.294	-2.294	2.294
120	1200	12.05	0	0	-6999	-9.31	-1.8	51.95	2.337	-2.337	2.337
120	1300	12	0	0	-6999	-9.21	-1.789	51.54	2.324	-2.324	2.324
120	1400	11.97	0	0	-6999	-9.15	-1.772	51.25	2.302	-2.302	2.302
120	1500	11.94	0	0	-6999	-9.11	-1.764	51.02	2.291	-2.291	2.291
120	1600	11.9	0	0	-6999	-9.03	-1.727	50.78	2.243	-2.243	2.243
120	1700	11.86	0	0	-6999	-8.9	-1.756	50.59	2.281	-2.281	2.281
120	1800	11.82	0	0	-6999	-8.97	-1.67	51.17	2.168	-2.168	2.168
120	1900	11.75	0	0	-6999	-11.63	3.033	61.21	-3.939	3.939	-3.939
120	2000	11.7	0	0	-6999	-21.9	21.7	99	-28.18	28.18	-28.18
120	2100	11.65	0	0	-6999	-47.29	94.3	239.2	-122.5	122.5	-122.5
120	2200	11.65	0	0	-6999	-83.3	170.5	424.9	-221.4	221.4	-221.4
120	2300	11.64	0	0	-6999	-120.8	232.4	581.3	-301.8	301.8	-301.8
121	0	11.65	0	0	-6999	-125.2	235.8	592.5	-306.2	306.2	-306.2
121	100	11.69	0	0	-6999	-140.2	256.9	648.1	-333.6	333.6	-333.6
121	200	11.75	0	0	-6999	-160.2	309.3	729	-401.7	401.7	-401.7
121	300	11.84	0	0	-6999	-153.3	299.6	683.6	-389.1	389.1	-389.1
121	400	11.94	0	0	-6999	-132.4	232.4	576.3	-301.9	301.9	-301.9
121	500	12.03	0	0	-6999	-108.1	183	447.3	-237.7	237.7	-237.7

TROUT LAKE PV/HYBRID PVPGS
COMPLETE HOURLY VALUES RECORDED Table 2
- May.1-31,1987

Day	Hour	Refrnce TempTP	Gen Hr Output EG	Inv.Hr Output EIO	Inv.Hr Input EII	ArrayHr Output EA	BatChgr Output ECH	Bat.Net Energy EB	Total AC Load ELA	Engy to BatChgr EC	GenLoad Direct EGD
121	600	12.11	0	0	-6999	-66.28	101.7	270.6	-132	132	-132
121	700	12.18	0	0	-6999	-34.87	48.08	166.4	-62.44	62.44	-62.44
121	800	12.23	0	0	-6999	-22.87	19.98	103.3	-25.95	25.95	-25.95
121	900	12.28	0	0	-6999	-17.62	10.7	81.8	-13.9	13.9	-13.9
121	1000	12.33	0	0	-6999	-12.85	3.349	65.17	-4.349	4.349	-4.349
121	1100	12.37	0	0	-6999	-9.87	-1.566	55.18	2.034	-2.034	2.034
121	1200	12.38	0	0	-6999	-9.57	-1.81	54.26	2.35	-2.35	2.35
121	1300	12.39	0	0	-6999	-9.5	-1.797	53.9	2.334	-2.334	2.334
121	1400	12.39	0	0	-6999	-9.45	-1.786	53.56	2.32	-2.32	2.32
121	1500	12.38	0	0	-6999	-9.4	-1.777	53.16	2.307	-2.307	2.307
121	1600	12.35	0	0	-6999	-9.25	-1.768	52.71	2.296	-2.296	2.296
121	1700	12.34	0	0	-6999	-9.16	-1.76	52.5	2.286	-2.286	2.286
121	1800	12.31	0	0	-6999	-9.26	-1.651	52.67	2.144	-2.144	2.144
121	1900	12.25	0	0	-6999	-11.59	2.795	60.32	-3.63	3.63	-3.63
121	2000	12.19	0	0	-6999	-22.13	20.57	98.8	-26.71	26.71	-26.71
121	2100	12.17	0	0	-6999	-47.82	92.3	242.3	-119.9	119.9	-119.9
121	2200	12.17	0	0	-6999	-81.8	167.8	420	-218	218	-218
121	2300	12.18	0	0	-6999	-118.8	229.7	573	-298.3	298.3	-298.3
122	0	12.2	0	0	-6999	-143.5	281.1	672.3	-365	365	-365
122	100	12.24	0	0	-6999	-139.1	263.3	637.7	-342	342	-342
122	200	12.27	0	0	-6999	-119.5	216.1	536.4	-280.6	280.6	-280.6
122	300	12.3	0	0	-6999	-150.2	272.6	654.4	-354	354	-354
122	400	12.36	0	0	-6999	-132.8	233.1	573.7	-302.8	302.8	-302.8
122	500	12.43	0	0	-6999	-102.9	162.5	418.3	-211	211	-211
122	600	12.5	0	0	-6999	-63.79	92.1	250.6	-119.7	119.7	-119.7
122	700	12.56	0	0	-6999	-36.22	44.78	161.7	-58.16	58.16	-58.16
122	800	12.62	0	0	-6999	-26.53	24.25	113.2	-31.49	31.49	-31.49
122	900	12.67	0	0	-6999	-16.65	9.83	81.4	-12.76	12.76	-12.76
122	1000	12.73	0	0	-6999	-13.25	3.712	66.36	-4.821	4.821	-4.821
122	1100	12.77	0	0	-6999	-9.7	-1.823	55.24	2.368	-2.368	2.368
122	1200	12.8	0	0	-6999	-9.55	-1.807	54.2	2.347	-2.347	2.347
122	1300	12.8	0	0	-6999	-9.56	-1.795	53.82	2.331	-2.331	2.331
122	1400	12.78	0	0	-6999	-9.77	-1.546	53.5	2.008	-2.008	2.008
122	1500	12.76	0	0	-6999	-9.6	-1.73	53.22	2.247	-2.247	2.247
122	1600	12.73	0	0	-6999	-9.61	-1.766	52.96	2.293	-2.293	2.293
122	1700	12.69	0	0	-6999	-9.4	-1.758	52.66	2.283	-2.283	2.283
122	1800	12.66	0	0	-6999	-9.44	-1.605	52.49	2.084	-2.084	2.084
122	1900	12.61	0	0	-6999	-10.87	1.419	56.98	-1.843	1.843	-1.843
122	2000	12.56	0	0	-6999	-15.96	9.33	73.8	-12.12	12.12	-12.12
122	2100	12.49	0	0	-6999	-18.8	14.06	86.7	-18.25	18.25	-18.25
122	2200	12.44	0	0	-6999	-47.75	79.4	230.6	-103.1	103.1	-103.1
122	2300	12.41	0	0	-6999	-118.6	227.7	568.5	-295.7	295.7	-295.7
123	0	12.42	0	0	-6999	-143.8	279.5	674.3	-363	363	-363
123	100	12.45	0	0	-6999	-158.1	311.2	730	-404.2	404.2	-404.2
123	200	12.48	0	0	-6999	-110.7	202	509.5	-262.4	262.4	-262.4
123	300	12.55	0	0	-6999	-104	179.1	459	-232.6	232.6	-232.6
123	400	12.57	0	0	-6999	-126.8	212.8	533.5	-276.4	276.4	-276.4
123	500	12.7	0	3.6	-6999	-80	126.8	324.3	-161.1	164.7	-164.7

TROUT LAKE PV/HYBRID PVPGS
COMPLETE HOURLY VALUES RECORDED Table 2
- May.1-31,1987

Day	Hour	Refrnce TempTP	Gen Hr Output EG	Inv.Hr Output EIO	Inv.Hr Input EII	ArrayHr Output EA	BatChgr Output ECH	Bat.Net Energy EB	Total AC Load ELA	Engy to BatChgr EC	GenLoad Direct EGD
123	600	12.74	0	0	-6999	-48.37	63.7	199.2	-82.7	82.7	-82.7
123	700	12.77	0	0	-6999	-31.18	36.55	145	-47.47	47.47	-47.47
123	800	12.78	0	0	-6999	-23.37	21.25	108	-27.59	27.59	-27.59
123	900	12.79	0	0	-6999	-15.62	7.75	77.8	-10.07	10.07	-10.07
123	1000	12.79	0	0	-6999	-12.32	2.726	64.52	-3.54	3.54	-3.54
123	1100	12.78	0	0	-6999	-10.14	-1.516	55.36	1.968	-1.968	1.968
123	1200	12.77	0	0	-6999	-9.81	-1.805	54.13	2.344	-2.344	2.344
123	1300	12.73	0	0	-6999	-9.69	-1.792	53.76	2.328	-2.328	2.328
123	1400	12.68	0	0	-6999	-9.61	-1.782	53.44	2.314	-2.314	2.314
123	1500	12.61	0	0	-6999	-9.56	-1.772	53.16	2.302	-2.302	2.302
123	1600	12.54	0	0	-6999	-9.5	-1.764	52.91	2.291	-2.291	2.291
123	1700	12.46	0	0	-6999	-9.46	-1.756	52.66	2.281	-2.281	2.281
123	1800	12.37	0	0	-6999	-9.69	-1.138	52.98	1.478	-1.478	1.478
123	1900	12.29	0	0	-6999	-13.06	5.422	65.78	-7.04	7.04	-7.04
123	2000	12.19	0	0	-6999	-27.66	29.64	117.7	-38.49	38.49	-38.49
123	2100	12.1	0	0	-6999	-41.67	63.77	189.1	-82.8	82.8	-82.8
123	2200	12.05	0	0	-6999	-61.79	108.1	293.5	-140.3	140.3	-140.3
123	2300	12.01	0	0	-6999	-95	171.9	449.3	-223.3	223.3	-223.3
124	0	12	0	0	-6999	-142.2	277.4	662.6	-360.3	360.3	-360.3
124	100	12.03	0	0	-6999	-159	310.7	730	-403.5	403.5	-403.5
124	200	12.08	0	0	-6999	-163	313.4	738	-407	407	-407
124	300	12.18	0	0	-6999	-148.5	273.2	655.6	-354.8	354.8	-354.8
124	400	12.26	0	0	-6999	-99.3	168.9	435.9	-219.3	219.3	-219.3
124	500	12.35	0	0	-6999	-102	158.5	411.4	-205.8	205.8	-205.8
124	600	12.42	0	0	-6999	-69.49	99.3	270.1	-129	129	-129
124	700	12.46	0	0	-6999	-28.91	32.93	132.9	-42.77	42.77	-42.77
124	800	12.5	0	0	-6999	-20.05	16.42	95.6	-21.33	21.33	-21.33
124	900	12.54	0	0	-6999	-17.42	10.99	84	-14.27	14.27	-14.27
124	1000	12.56	0	0	-6999	-12.48	2.688	65.12	-3.491	3.491	-3.491
124	1100	12.57	0	0	-6999	-10.27	-1.478	55.67	1.919	-1.919	1.919
124	1200	12.56	0	0	-6999	-9.97	-1.797	54.12	2.334	-2.334	2.334
124	1300	12.55	0	0	-6999	-9.85	-1.792	53.75	2.327	-2.327	2.327
124	1400	12.51	0	0	-6999	-9.68	-1.781	53.42	2.313	-2.313	2.313
124	1500	12.48	0	0	-6999	-9.63	-1.772	53.14	2.301	-2.301	2.301
124	1600	12.43	0	0	-6999	-9.51	-1.763	52.88	2.29	-2.29	2.29
124	1700	12.37	0	0	-6999	-9.51	-1.755	52.64	2.28	-2.28	2.28
124	1800	12.31	0	0	-6999	-9.72	-1.254	53.21	1.628	-1.628	1.628
124	1900	12.23	0	0	-6999	-12.92	4.178	64.28	-5.426	5.426	-5.426
124	2000	12.15	0	0	-6999	-23.99	22.27	102.3	-28.92	28.92	-28.92
124	2100	12.1	0	0	-6999	-49.66	95	245.5	-123.4	123.4	-123.4
124	2200	12.1	0	0	-6999	-81.5	171.2	424.9	-222.3	222.3	-222.3
124	2300	12.13	0	0	-6999	-115.2	223.3	559.1	-290	290	-290
125	0	12.19	0	0	-6999	-139.8	282.8	647	-367.2	367.2	-367.2
125	100	12.25	0	0	-6999	-154.4	306.8	708	-398.5	398.5	-398.5
125	200	12.36	0	0	-6999	-146.8	295.8	656.2	-384.2	384.2	-384.2
125	300	12.49	0	0	-6999	-143.7	275.6	632.2	-357.9	357.9	-357.9
125	400	12.61	0	0	-6999	-121.4	214.9	525.2	-279.1	279.1	-279.1
125	500	12.7	0	0	-6999	-93.5	147.7	388.4	-191.8	191.8	-191.8

TROUT LAKE PV/HYBRID PVPGS
COMPLETE HOURLY VALUES RECORDED Table 2
- May.1-31,1987

Day	Hour	Refrnce TempTP	Gen Hr Output EG	Inv.Hr Output EIO	Inv.Hr Input EII	ArrayHr Output EA	BatChgr Output ECH	Bat.Net Energy EB	Total AC Load ELA	Engy to BatChgr EC	GenLoad Direct EGD
125	600	12.77	0	0	-6999	-69.79	100.6	271.8	-130.6	130.6	-130.6
125	700	12.84	0	0	-6999	-34	40.45	152.1	-52.53	52.53	-52.53
125	800	12.89	0	0	-6999	-27.48	26.08	118	-33.88	33.88	-33.88
125	900	12.95	0	0	-6999	-19.03	12.85	87.1	-16.68	16.68	-16.68
125	1000	13	0	0	-6999	-12.77	2.686	63.92	-3.489	3.489	-3.489
125	1100	13.07	0	0	-6999	-10.1	-1.804	54.75	2.343	-2.343	2.343
125	1200	13.11	0	0	-6999	-9.85	-1.802	54.06	2.341	-2.341	2.341
125	1300	13.13	0	0	-6999	-9.74	-1.79	53.67	2.324	-2.324	2.324
125	1400	13.17	0	0	-6999	-9.68	-1.779	53.34	2.31	-2.31	2.31
125	1500	13.19	0	0	-6999	-9.56	-1.769	53.06	2.297	-2.297	2.297
125	1600	13.19	0	0	-6999	-9.67	-1.753	52.8	2.277	-2.277	2.277
125	1700	13.2	0	0	-6999	-9.39	-1.752	52.55	2.276	-2.276	2.276
125	1800	13.2	0	0	-6999	-9.56	-1.745	52.64	2.267	-2.267	2.267
125	1900	13.17	0	0	-6999	-11.23	1.903	58.75	-2.471	2.471	-2.471
125	2000	13.14	0	0	-6999	-23.82	21.33	101	-27.7	27.7	-27.7
125	2100	13.12	0	0	-6999	-36	54.75	168.1	-71.1	71.1	-71.1
125	2200	13.12	0	0	-6999	-82.4	166.3	418	-215.9	215.9	-215.9
125	2300	13.12	0	0	-6999	-97.6					

TROUT LAKE PV/HYBRID PVPGS
COMPLETE DAILY VALUES RECORDED Table 1
- May 1-31,1987

Day	Hour	BatVolt Maximum VB	Timeof VBmax	Ambient TempMx TAm	Timeof TAmax	Cell TempMx TCmax	Timeof TCmax	Battery TempMx TBm	timeof TBmax
120	0	31.42	27	17.07	329	42.11	146	14.03	504
121	0	31.42	2320	20.39	421	26.59	130	13.47	929
122	0	31.51	50	14.67	204	33.54	243	15.4	1018
123	0	31.38	12	16.34	439	29.49	133	16.55	939
124	0	31.35	105	11.88	2359	32.56	107	17.42	435
125	0	31.28	58	13.05	214	34.51	2328	17.16	746
126	0	31.22	2359	16.63	549	40.49	203	17.6	934
127	0	31.26	44	11.86	222	33.73	142	18.12	743
128	0	31.21	151	10.43	513	36.15	130	18.25	849
129	0	31.39	2346	12.19	254	35.43	35	18.12	421
130	0	31.31	128	10.83	258	38.31	19	17.58	828
131	0	30.89	10	10.45	347	24.1	13	15.87	125
132	0	31.74	0	1.924	2310	25.73	2342	13.33	1
133	0	31.82	23	9.14	759	30.18	120	14.08	1110
134	0	31.96	2352	3.68	130	31.57	0	11.75	927
135	0	31.88	4	5.33	2343	34.46	117	12.79	942
136	0	31.79	2355	11.14	337	39.37	207	12.85	340
137	0	31.8	33	7.19	744	29.6	58	13.48	912
138	0	31.72	26	6.823	526	34.7	2345	13.06	838
139	0	31.76	39	13.54	2354	35.75	214	13.18	859
140	0	31.52	25	19.16	722	42.01	0	14.27	858
141	0	31.36	2323	22.33	428	47.28	121	15.51	341
142	0	31.31	148	18.47	725	36.17	0	15.72	1022
143	0	31.26	1	22.04	422	45.63	109	16.96	428
144	0	31.3	220	15.62	110	40	0	18.15	313
145	0	31.27	42	16.98	751	43.44	141	18.42	456
146	0	31.23	113	22.46	703	46.28	34	18.87	410
147	0	31.11	115	23.04	750	43.77	409	19.36	419
148	0	30.99	2343	25.33	712	47.45	154	20.28	1032
149	0	31.03	33	24.37	353	39.81	54	21.62	413
150	0	31.09	142	17.99	726	36.08	2330	20.53	144
151	0	29.69	2116	13.6	505	41.64	2354	18.8	57

TROUT LAKE PV/HYBRID PVPGS
COMPLETE DAILY VALUES RECORDED Table 2
- May 1-31,1987

Day	RefTemp Max TPmax	Timeof TPmax	Battery MinVolt VB	Timeof VBmin	Ambient TempMn TAm	Timeof TAmin	Cell TemMin TCmin	Timeof TCmn	Battery TemMin TBm	Timeof TBmin
120	10.93	1454	26.11	1830	1.749	1847	.573	1801	10.65	25
121	12.24	609	26.06	1804	4.899	1832	3.045	1759	10.15	112
122	12.41	1337	26.1	1811	1.7	1744	.397	1747	11.56	14
123	12.81	1207	26.05	1819	1.823	1250	-2.347	1300	13.08	10
124	12.8	825	26.06	1803	3.721	1712	2.321	1711	13.13	132
125	12.57	1024	26.05	1756	-.367	1856	-.244	1103	13.78	1
126	13.2	1604	25.99	1813	4.45	1815	1.305	1814	13.48	2343
127	13.28	1049	25.99	1825	-.662	1616	-3.425	1620	14.43	2222
128	13.12	845	26.01	1754	-1.505	1839	-4.37	1712	14.62	2210
129	12.82	821	26.06	1756	-3.118	1700	-6.223	1656	13.31	2249
130	12.45	903	26.07	1751	-3.858	1804	-7.11	1644	13.63	2332
131	11.49	32	25.9	2014	-3.112	2326	-2.483	1919	13.34	2356
132	8.77	1	26.14	1	-10.01	1801	-10.13	1827	8.57	2257
133	7.98	1158	26.17	1741	-1.784	2004	-4.364	1645	8.78	133
134	7.6	1	26.33	1749	-4.291	1843	-4.373	1735	8.53	2327
135	7.56	1355	26.24	1735	-1.012	49	-2.702	1453	8.42	2324
136	8.33	1215	26.26	1741	.93	1745	.101	1430	9.19	2222
137	8.8	1231	26.25	1728	-3.489	1745	-7.18	1710	9.53	32
138	8.8	625	26.31	1742	-6.51	1757	-10.65	1703	9.75	2148
139	8.75	1125	26.29	1731	-3.434	1723	-7.86	1701	9.51	38
140	10.34	2358	26.15	1726	3.367	1753	.925	1320	11.05	1
141	12.21	1550	26.17	1737	1.126	1759	-1.637	1747	12.51	1
142	12.9	2356	26.16	1730	5.994	1309	4.255	1727	12.93	7
143	14.13	2353	26.13	1716	4.938	1809	5.542	1643	13.95	2
144	14.86	1421	26.07	1743	3.535	1841	1.477	1739	15.12	2338
145	15.08	1041	26.15	1730	.198	1749	-2.599	1705	15.44	27
146	15.4	2358	26.09	1717	5.946	1713	3.231	1711	15.51	217
147	16.15	1136	26.1	1714	2.2	1717	-.007	1718	16.03	14
148	17	1429	26	1728	7.56	2201	6.518	1642	17.32	5
149	18.21	1111	26	1724	7.99	1841	5.985	1733	17.88	4
150	17.36	1	26.28	1741	5.087	1744	3.708	1407	17.23	137
151	16.54	34	26.36	1814	6.259	2245	7.55	1357	16.5	2115

TROUT LAKE PV/HYBRID PVPGS
COMPLETE DAILY VALUES RECORDED Table 3 tldc3
-May 1-31,1987

Day	RefTemp Min TPmin	Timeof TPmin	Ambient Average TA	Max15sc Array OutE	Timeof EAmax	Global Irradn IGto	Total Irradn Ttota	G Max Irradc IGmax	Timeof IGmax	T Max Irradc IAmax	Timeof IAmax
120	9.39	1	9.23	-.038	1349	4075.4	4525.6	0	18	693.14	200
121	10.69	1	11.15	-.037	1714	3465.8	3960.2	0	0	856.11	113
122	11.65	1	9.09	-.038	1650	5517.5	6867.2	0	0	794.25	144
123	12.2	1	9.03	-.039	1728	5235.1	5915.2	0	0	876.9	208
124	12	2350	7.29	.016	436	4808.7	5550.9	0	3.6	890.34	137
125	12.01	1	7.18	-.039	1724	5422.9	6691.1	0	0	902.86	257
126	12.19	1	11.1	-.039	1639	5366.5	6254	0	0	813.79	2343
127	12.66	2230	5.197	-.039	1616	5653.2	6617.7	0	0	766.17	218
128	12.45	2231	4.124	-.04	1710	5513.4	6867.8	0	0	835.79	233
129	11.95	2129	3.618	-.04	1650	4803	5515.6	0	0	966.23	254
130	11.46	2331	2.326	-.04	1634	5201.9	5913.6	0	0	896.27	139
131	8.78	2353	2.531	-.04	1804	1534	1451.4	0	0	577.23	10
132	7.18	2234	-3.356	-.04	1709	342.62	3747.6	0	3.6	78.663	0
133	7.33	1	1.982	.132	1110	3733.4	5356.8	0	10.8	980.57	258
134	6.757	2127	-1.19	-.04	1653	3887.9	4465.7	0	0	878.24	2352
135	6.799	1	1.645	-.04	1509	5004.6	5373.3	0	0	916.01	124
136	7.44	1	4.43	-.04	1641	5136.4	5462.5	0	0	929.13	219
137	8.06	1	2.832	-.039	1642	5311.9	5229.3	0	0	885.76	32
138	8.02	2122	.681	-.039	1615	5465.8	5449.2	0	0	998.54	331
139	8.07	1	4.905	-.039	1601	5126.2	5662.5	0	0	859.3	420
140	8.59	1	10.76	-.039	1643	6001.3	6677.3	0	0	777.37	219
141	10.34	1	11.05	-.039	1618	5613.5	6059.8	0	0	834.64	2321
142	12.21	1	10.66	-.039	1607	4468.1	4675.2	0	0	811.16	247
143	12.9	1	13.6	-.038	1644	5304.7	5986.4	0	0	830.71	404
144	14.13	1	9.13	-.038	1616	5055.8	5423.4	0	0	1003.6	234
145	14.42	2059	8.79	-.039	1618	4641.5	5337.5	0	0	937.4	27
146	14.52	1	14.45	-.038	1412	4589.3	4930	0	0	1010.1	223
147	15.4	1	10.86	-.039	1617	4507.6	5239.2	0	0	853.72	326
148	15.8	1	15.34	-.039	1615	5637.7	6354.8	0	0	795.86	2343
149	16.95	1	15.14	-.039	1552	4985	4515.7	0	0	938.17	132
150	16.51	2302	10.69	-.039	1704	3928.6	3902.1	0	0	1162.9	219
151	15.99	2317	9.63	-.039	1737	4304.8	4072.8	0	0	1021.9	320

TROUT LAKE PV/HYBRID PVPGS
COMPLETE DAILY VALUES RECORDED Table 4 tldc4
- May 1-31,1987

Day	GenDay Total EGtot	Invertr OutTot EIO	Invertr InpTot EI	Array OutTot EA	BatChgr OutTot ECH	NetBat Input EB	AC Tot Load ELAC	BatChgr Input ECHI
120	955.54	53	-99999	-239.25	371.58	1073.9	-1914.1	1932.1
121	917.95	111	-99999	-222.84	316.75	1044.4	-1638.5	1638.5
122	990.03	144	-99999	-337.8	562.06	1568	-2916.2	2916.2
123	1032.5	121	-99999	-308.44	480.04	1402.9	-2493.3	2493.3
124	1072.3	137	-99999	-291.05	448.8	1334.3	-2342.9	2346.5
125	953.82	113	-99999	-330.95	544.39	1525.2	-2821.2	2821.2
126	1062.8	2343	-99999	-315.23	506.07	1430.3	-2620.9	2620.9
127	971.81	112	-99999	-333.49	539.37	1513.4	-2802.5	2802.5
128	1025.9	216	-99999	-335.49	558.28	1541.9	-2897.8	2897.8
129	1094.3	2346	-99999	-288.36	445.67	1309.6	-2315.6	2315.6
130	1072.8	128	-99999	-306.81	478.13	1385.6	-2486	2486
131	652.17	10	-99999	-116.57	106.42	529.54	-554.38	554.38
132	967.47	2350	-99999	-152.52	296.61	905.07	-1537.9	1541.5
133	1150.1	207	-99999	-273.7	443.92	1332	-2294.3	2305.1
134	1220.7	2352	-99999	-249.2	364.6	1152.9	-1893.7	1893.7
135	1240.3	124	-99999	-293.33	443.42	1313.6	-2298.8	2298.8
136	1029.7	206	-99999	-290.99	449.35	1284.7	-2338.2	2338.2
137	1045	51	-99999	-289.81	427.46	1257.5	-2224.9	2224.9
138	998.52	26	-99999	-297.87	444.92	1299	-2308.7	2308.7
139	1059.3	38	-99999	-297.76	463.66	1334.9	-2400.6	2400.6
140	910.04	105	-99999	-331.48	548.69	1456.5	-2852.7	2852.7
141	926.57	140	-99999	-301.63	494.24	1311.4	-2565	2565
142	886.79	147	-99999	-259.56	375.29	1170.1	-1948.3	1948.3
143	873.54	136	-99999	-303.08	484.36	1363.8	-2517.2	2517.2
144	1055.3	220	-99999	-289.81	438.3	1302.2	-2266.4	2266.4
145	1075.4	43	-99999	-275.14	430	1252.1	-2235.8	2235.8
146	1038.9	113	-99999	-264.79	394.32	1190.3	-2052.6	2052.6
147	975.84	14	-99999	-272.02	420.2	1247.8	-2196.1	2196.1
148	927.09	2343	-99999	-313.45	512.7	1394.5	-2663.8	2663.8
149	967.54	132	-99999	-263.36	360.7	1138.8	-1876.7	1876.7
150	1133.5	219	-99999	-162.83	290.65	614.92	-1510	1510
151	913.91	320	-99999	-152.32	301.29	512.08	-1562.3	1562.3

TROUT LAKE PV/HYBRID PVPGS
COMPLETE DAILY VALUES RECORDED Table 5 tldc5
- May 1-31,1987

Day	GenDir toLoad EGLD	Gen. Start Time	Gen Stop Time	Gen Run Time	GRT Total toDate	Accum Gen Starts	Batt Invent kWh	Hours EA>3.6	Hours IA>50
120	-1932.1	0	0	0	12.62	2	135.5	0	12
121	-1638.5	0	0	0	12.95	2	139.6	0	11
122	-2916.2	0	0	0	13.28	2	145.9	0	13
123	-2493.3	0	0	0	13.61	2	151.5	0	12
124	-2346.5	0	0	0	13.95	2	156.9	0	13
125	-2821.2	0	0	0	14.28	2	163	0	13
126	-2620.9	0	0	0	14.61	2	168.7	0	13
127	-2802.5	0	0	0	14.94	2	174.7	0	12
128	-2897.8	0	0	0	15.28	2	180.9	0	13
129	-2315.6	0	0	0	15.61	2	186.1	0	13
130	-2486	0	0	0	15.94	2	191.7	0	13
131	-554.38	0	0	0	16.28	2	193.8	0	9
132	-1541.5	0	0	0	16.61	2	197.4	0	13
133	-2305.1	0	0	0	16.94	2	202.7	0	13
134	-1893.7	0	0	0	17.27	2	207.3	0	13
135	-2298.8	0	0	0	17.61	2	212.6	0	13
136	-2338.2	0	0	0	17.94	2	217.7	0	13
137	-2224.9	0	0	0	18.27	2	222.7	0	13
138	-2308.7	0	0	0	18.6	2	227.9	0	13
139	-2400.6	0	0	0	18.94	2	233.3	0	13
140	-2852.7	0	0	0	19.27	2	239.1	0	13
141	-2565	0	0	0	19.6	2	244.3	0	13
142	-1948.3	0	0	0	19.94	2	249	0	13
143	-2517.2	0	0	0	20.27	2	254.5	0	14
144	-2266.4	0	0	0	20.6	2	259.7	0	14
145	-2235.8	0	0	0	20.93	2	264.7	0	14
146	-2052.6	0	0	0	21.27	2	269.4	0	14
147	-2196.1	0	0	0	21.6	2	274.4	0	13
148	-2663.8	0	0	0	21.93	2	280	0	14
149	-1876.7	0	0	0	22.26	2	284.6	0	12
150	-1510	0	0	0	22.6	2	287	0	14
151	-1562.3	0	0	0	22.93	2	289.1	0	14